INTERSECTION PERFORMANCE AND THE NEW ZEALAND LEFT TURN RULE

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Finally I would like to thank my family and friends for their support in particular my parents and proof readers, Alistair and Janet Wilkins. I wish to dedicate this thesis and the completion of my Masters Degree to my late Grandmother, Noni, who was my favourite person in the world as well as being correct punctuation and grammar's biggest supporter. I hope this meets her standards.

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Abstract

This thesis reports the use of Paramics microscopic simulation software to model the differences between the performance of ten Christchurch intersections under the existing New Zealand road rule which requires left turning vehicles to give way to vehicles turning right into the same road, and a changed rule that would see the right turning vehicle have priority.

Previous research concerning this issue is reviewed and the history of the existing road rule and recent moves to change it are discussed.

At each of the ten intersections a range of traffic volume combinations was assessed and the journey times and queue lengths were compared. The ten intersections represent a range of different layouts and forms of control including give way signs, stop signs and traffic signals.

The impact of a rule change on the use of shared lanes at intersections using a Paramics model of the Christchurch Central Business District, as developed for the Christchurch City Council, is also reported.

Conclusions are drawn about which types of intersections and traffic volume combinations are likely to be affected by a rule change. The features of intersections that contribute to this susceptibility are identified and conclusions drawn about whether positive or negative effects are likely.

It is concluded that there is no compelling intersection performance reason why the rule could not be changed. The successful implication of such change would require a review of the road network to identify critical intersections. Some monitoring and mitigation measures may also be required.

Glossary of Terms, Abbreviations and Acronyms

Definition of terms as they used in this thesis:

AADT	Average annual daily traffic volume.
Benefit cost ratio	The ratio of the present value of economic benefits derived by the community from transport system improvements over the present value costs of those improvements.
Calibration	Varying operational parameters within acceptable or specified ranges until the modelled outputs and observed outputs agree to an acceptable level of accuracy (Austroads, 2006).
CBD	Central business district.
Far side priority	The road rule under which the vehicle on the side furthest from the side road gets priority over the vehicle turning from the closer side of the road into the same side road. In New Zealand and countries that drive on the left this is also referred to as **left turn priority** or the **New Zealand left turn rule**. In this thesis far side priority is also referred to as the **existing rule**. This is illustrated in Figure 1-1.
Filtering turn	A turning movement that is permitted a signalised intersection, which conflicts with another traffic stream permitted to move at the same time.
Gap Acceptance	The acceptance of a gap in a traffic stream by a driver wishing to enter or cross that traffic stream.
Gap	The time interval between the departure at a point of one vehicle and the arrival at the same point of the next vehicle.
Grade separation	The separation of road, rail or other traffic so that crossing movements which would otherwise conflict are effected at different elevations.
Land Transport New Zealand	The Crown entity formed to promote land transport sustainability and safety, and allocate government funding for land transport (formerly the Land Transport Safety Authority).
Microscopic simulation (or Microsimulation)	The type of transportation modelling that models road networks by modelling the behaviour of every individual vehicle in the network.

Near side priority	The road rule under which the vehicle on the side closest to the side road gets priority over the vehicle turning from the further side of the road into the same side road. In New Zealand and countries that drive on the left this is also referred to as **right turn priority**. In this thesis near side priority is also referred to as the **changed rule**. This is illustrated in Figure 1-2.
Paramics	The microscopic simulation software package developed by SIAS Limited which has been used to model the intersections and networks investigated in this thesis.
SIDRA	Signalised and unsignalised intersection design and research aid. The analytical traffic analysis software developed by the Australia Road Research Board.
SCATS	Sydney Co-ordinated Adaptive Traffic System. The computer system developed by the Roads and Traffic Authority of New South Wales which used to co-ordinate and monitor traffic signal intersections in New Zealand.
Ministry of Transport	The New Zealand government's principal transport policy adviser.

Units

km/h	kilometres per hour
s/veh	seconds per vehicle
vpd	vehicles per day
vph	vehicles per hour

Abbreviations used in Figures, Tables and Graphs

Ex	Existing Rule
Ch	Changed Rule
L	left
T	through
R	right
LT	shared through and left lane
TR	shared through and right lane
N	North Approach
E	East Approach
S	South Approach
W	West Approach

Examples of composite use:	NL	left turn from North approach
	NTR	shared through and right lane on North approach

Rd	Road
St	Street
Ave	Avenue
Mvt	Movement
s	Seconds

1 Introduction and Objectives

New Zealand appears to be the only country in the world where the road rules require a left turning vehicle to give way to a vehicle turning right into the same road (Hughes 1997). This rule will be referred to in this thesis as 'far side priority'. Elsewhere in the world, the vehicle turning from the far side (the right turning vehicle in New Zealand) is required to give way. This rule will be referred to in this thesis as 'near side priority'. This includes countries that drive on the right side of the road, where the left turner gives way to the right turner. The existing rule (far side priority) that applies in New Zealand is illustrated in Figure 1-1.

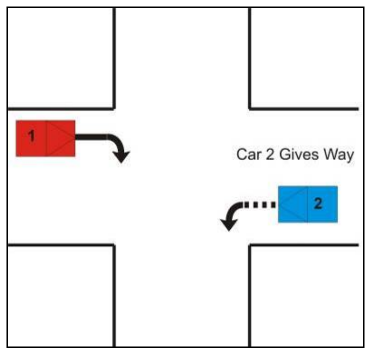


Figure 1-1 – Far Side Priority

Near side priority, that applies everywhere in the world except New Zealand, is illustrated in Figure 1-2.

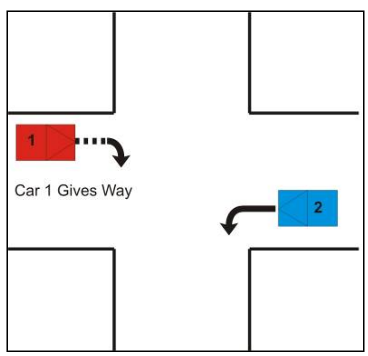


Figure 1-2 – Near Side Priority

Changing the New Zealand left turn rule became a particularly topical issue when a change to near side priority was included in the consultation draft of the Land Transport (Road User) Rule 2004 (Land Transport Safety Authority, 2002). The change had many supporters within the traffic engineering industry, as described later in Section 2.2, but was not included in the final version of the Land Transport (Road User) Rule 2004 so the debate goes on.

As also described later in Section 2.2, the main benefits of a rule change arise from road safety issues. Much research has been undertaken into the road safety elements of each rule. This thesis will look at the intersection performance side of the issue by investigating and comparing journey times and queue lengths under each rule. Some research has already been directed at intersection performance issues and this thesis will review this research then use a different traffic modelling software to investigate the issue further.

The objectives of this thesis are:

- To briefly investigate the history of the near side priority rule in New Zealand and identify any efficiency-related aspects
- To use microscopic simulation models to further investigate the impacts of changing the New Zealand left turn rule on the efficiency a range of real intersection types and volumes
- To use the models for testing of traffic volume, intersection layout and other parameter scenarios to draw conclusions about the wider implications of changing the rule for intersections around New Zealand

2 Literature Review

2.1 History

Far side priority was introduced in New Zealand in 1977 as part of a wider series of road rules that aimed to clarify and more clearly define the country's intersection priority rules. At the time it was expected that there would be a reduction in crashes and less delay for right turning traffic. However, following the change, intersection crashes increased by 2.5% (Hughes, 1997). In particular, accidents involving vehicles turning right either out of a side road or off a major road increased in both rural and urban areas. In rural areas accidents involving overtaking a right turning vehicle also increased although other rule changes were also considered to have contributed to this (Hughes, 1997).

The research of Hughes (1997) included an economic evaluation of changing both the New Zealand left turn rule and another give way rule that applies at uncontrolled T-junctions. The proposed change to this latter rule is illustrated in Figure 2-1.

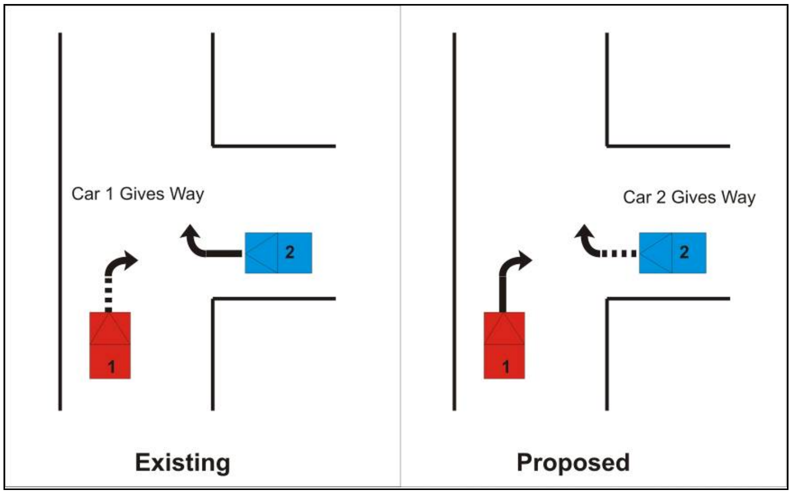


Figure 2-1 – Proposed T-Junction Rule change to near side priority

The proposed changed to this rule was to require all traffic on a road that terminates at an intersection to give way to all traffic on a road that continues through the intersection. This rule was not adopted in the Land Transport (Road User) Rule 2004 (Ministry of Transport, 2004).

The economic evaluation considered the combination of both the proposed rule change to near side priority and the T-junction rule and determined that there would be an associated social cost saving of NZ $28 million per year allowing for injury and non-injury crashes. No perceptible increase in delay for drivers was predicted and no delay cost or benefit was included in the economic analysis (Hughes, 1997).

The combined analysis gave a benefit cost ratio of 35:1 (Hughes, 1997). This means the benefits of the rule change to near side priority were 35 times the cost of changing the rules.

2.2 The Debate

The change to far side priority has been controversial ever since it was made in 1977. Support for a change back to near side priority gained particularly strong momentum leading up to the introduction of the Land Transport (Road User) Rule 2004 which included changes and clarification of a wide range of rules including changes to those involving pedestrian crossings, special vehicle lanes, slow vehicle bays, indicating at roundabouts, vehicle noise, bus seatbelts, vehicle lights, towing, parking, following, cycle helmets, and entering and leaving driveways.

A change to near side priority was included in consultation draft of the Land Transport (Road User) Rule 2004 (Land Transport Safety Authority, 2002) but was not included in the final version. This was despite having the support of road safety engineers, the Land Transport Safety Authority (now LTNZ), the Institute of Driving Instructors, the Automobile Association (AA), the IPENZ Transportation Group, the Minister of Transport, Minister of Transport Safety and the majority of the general public who submitted comments (IPENZ Transportation Group Management Committee, 2006).

The IPENZ Transportation Group, the technical group that represents New Zealand transportation professionals firmly supported the rule, publicly stating that more people would be injured the longer the change was deferred (IPENZ Transportation Group Management Committee, 2006). The AA held a similar view and opposed the current rule when it was introduced in 1977.

The dominant argument for a change is road safety. When the rule was changed in Victoria, road safety improvements were expected and eventuated (Hughes 1997). On 28 February 1993 the Australian state of Victoria changed from far side priority to near side priority. Following the change casualty intersection crashes reduced by 3.3% in urban areas and 1.5% in rural areas. The observation of Victorian traffic engineers was that increases in right turn delays were matched by decreases in left turn delays, although the impact on traffic flow was not formally evaluated.

The main expected benefit of a change to the rules is improved road safety, as shown by the analysis undertaken LTNZ and described in Chapter 2.1. It is estimated that a rule change to near side priority would prevent 173 injury crashes each year with an associated social cost saving of $22 million per year (IPENZ Transportation Group Management Committee, 2006). This is the result of a rule that is simpler and leads to easier decision making, more predictable driver behaviour and great consistency.

The estimated benefit cost ratio of the two rule change to near side priority was 424 (meaning that for every $1 of cost there are $424 worth of benefits). With possible increases in delay included, the benefit cost ratio remained above 50.

The common views of the parties referred to above were that the economic benefits of a rule change to near side priority were significant and that any delay in changing the rule would come at a high cost to society.

2.3 Is There Anything Wrong with the Current Rule?

After ten months of the rule change to far side priority being applied on 1 February 1977, the Ministry of Transport reported that driver compliance was approximately 55% based on their monitoring at various intersections (Thomson and Kammann, 1979).

Far side priority was criticised for being a change to established expectancy since it is an exception to a series of generally consistent road rules and a change to a conceptual system that drivers have become used to (Thomson and Kammann, 1979). Public outcry, confusion, delay and annoyance all resulted.

Allan (1985) described how the far side priority rule should never have been changed in 1977 because it was inefficient as well as being a road safety concern. One of the arguments presented to support this inefficiency was the simple point that a left turning vehicle, such as Car 2 depicted above in Figure 1-1, can clear the intersection more quickly than the right turning vehicle (Car 1 in Figure 1-1), simply because it has less distance to travel. Therefore far side priority which requires the left turning vehicle to give way is less efficient because the left turning vehicle incurs more delay from the right turning vehicle than the right turning vehicle would from the left turning vehicle (Allan, 1985).

The public consultation work undertaken by the LTSA revealed the following common reasons cited by the general public as to why the proposed rule change to near side priority was supported (LTSA, 2002):

- the pre-1977 rule was simpler to apply and led to fewer crashes
- New Zealand’s approach is unique and greater uniformity with the rest of world would produce safety benefits
- “Smoother” traffic flow

There are also other reasons why the current rule is considered to be a contributing factor to accidents (Hughes, 1997). These include:

- Right turning drivers focus on whether a left turning vehicle is indicating and whether it will give way and can fail to notice a through vehicle/cyclist/motorcyclist coming from behind or swinging out to overtake the left turner
- Right turning drivers can think a vehicle is turning left when they are indicating only a lane change or their indicator has not cancelled from a prior turn
- Left turning vehicles giving way can obstruct the view for a vehicle coming out of the side road

2.4 The Experience in Victoria

Far side priority was used in the Australian State of Victoria until 1993 when the state reverted to near side priority, becoming consistent with the rest of Australia and the world. The primary objective of the rule change to near side priority was to reduce the number of accidents involving right turning vehicles, particular those involving the vehicle turning left into the same road. The secondary objectives were to make Victoria consistent with the rest of Australia and to reduce delays (Parliamentary Counsel Victoria, 1993).

Far side priority was originally adopted to assist with trams in Victoria's largest city, Melbourne. The trams were hindered by right turning vehicles waiting in the centre of the road. A change to the operation of trams in Melbourne since 1983 and the use of right turn lanes, hook turns and right turn phases at traffic signals has progressively reduced the delay caused to trams by right turning vehicles.

A detailed accident analysis was undertaken prior to the change and this predicted accident savings in the order of AUS $5.2 million per year (Parliamentary Counsel Victoria, 1993).

It was predicted that more vehicles would use the left lane in multi-lane situations as they would no longer be delayed by left turning vehicles having to give way. Right turn delays were expected to increase only slightly and traffic flow was predicted to significantly improve (Parliamentary Counsel Victoria, 1993).

Assessment of the rule after implementation showed:

- A reduction in the number of crashes anticipated to be affected by the rule change to near side priority
- Fewer pedestrian crashes
- An overall reduction in crashes twice that expected
- Improved operation of the Melbourne traffic system
- Virtually no impact on tram services

- Simpler and safer intersections

2.5 Intersection Performance and the Two Rules

In relation to efficiency and intersection performance the expected differences between the two rules vary. The IPENZ Transportation Group states that on busy roads the current left turn versus right turn rule doesn't improve right turn delays (IPENZ Transportation Group Management Committee, 2006).

Hughes (1997) researched impacts on traffic flow using the intersection performance analysis package SIDRA to compare the two rules. SIDRA is described later in Section 2.9.5.

In relation to intersection performance Hughes drew the following conclusion based on computer modelling and the experience in Victoria:

- The existing rule can disrupt traffic flow and be inefficient as it gives rise to situations where both left and right turning vehicles are required to give way to other traffic and block through traffic
- Overall drivers will not experience a perceptible increase in delay, there will be less delay turning left but more turning right
- With the increased right turn delay some intersections may experience increased queue lengths and there may be a need for layout changes, flush medians or in some cases, conversion of priority intersections to traffic signals
- Critical intersections should be identified and improved before any rule change to near side priority
- Overall traffic will flow more smoothly, as observed in Victoria
- Simplification of driver decisions may result in less hesitance and contribute to smoother flow
- There is potential for drivers may change their choice of routes with some left turns becoming easier and come right turns becoming more difficult
- There is improved use of the left lane of multilane roads due to there being less potential for blockages caused by left turning vehicles giving way and therefore more efficiency

Hughes (1997) concluded that overall, drivers would perceive no increase in delay following a rule change to near side priority. Right turning vehicles would experience less delay and left turning vehicles more delay. The economic analysis of the rule was undertaken on the basis that there would be no overall change in delay. A sensitivity test was also undertaken to assess the impact of an increase in delay as a result of the rule change to near side priority. Hughes (1997) noted that SIDRA was not the ideal tool for comparing the two rules (personal communication T. Hughes, 22 January 2008). This is discussed further in Section 2.9.5.

Daltrey (1980) prepared a paper comparing the two rules. He concluded that there was no reason why the State of Victoria could not change to left turn priority to become consistent with the rest of Australia.

Daltrey (1980) reviewed various delay analyses that have compared the two rules. He described computer simulation of T-intersections that assumed equal flows in the range of 500 to 2,000 vehicles per hour in each direction on the major road, equal numbers of right and left turners forming 20% of the major flow and one hundred vehicles per hour turning left and right out of the minor road. The results of the simulation showed that for the overall intersection delay the right hand priority rule resulted in slightly less delay than the left hand priority rule. The difference was slightly greater when just the major road delay was considered.

He concludes that for maximum flow rates of 1,000 vehicles per hour an increase in delay of around one second is experienced under the left turn priority rule. The paper discusses other previous work and concludes that delays may increase up to 16-20% for flows in the range 600 to 1,000 vehicles per hour and also suggests that far side priority reduces delay to minor road vehicles.

Other researchers including Quayle (1980) and Morgan (1988) have compared the two rules however their work has focused more on safety issues, decision making processes for drivers, operational issues such as interaction with trams in Victoria and the overall structure of road rules in each country.

2.6 Traffic Modelling

This thesis uses microscopic simulation modelling. There are four broad types of traffic modelling as identified by Austroads (2006). These are:

- Analytical modelling
- Microscopic simulation
- Macroscopic simulation
- Hybrid simulation

The Austroads (2006) definitions of these techniques are as follows:

Analytical *- this technique relates directly to traffic flow theory and is often a set of equations governing driver behaviour such as gap acceptance, lane changing, car-following or platoon dispersion. The combination of analytical models can constitute a more complex analytical model for traffic analysis. Individual sets of analytical equations can also act as sub-models in other modelling techniques. Analytical modelling is sometimes also known as microscopic modelling.*

***Microscopic simulation** – the movement of a vehicle in a microscopic simulation is traced through a road network over time at a small time increment of a fraction of a second. A detailed simulation of vehicle-road interaction under the influence of a control measure is therefore possible. This technique is useful for a wide range of applications but requires more computational resources. Random number generators are involved and the calibration of these models requires more effort, and it is difficult to optimise model parameters e.g. signal settings.*

***Macroscopic simulation -** vehicles in a macroscopic simulations are no longer simulated individually. Vehicle movements are often simulated as packets or bunches in a network with a time step of one or several seconds. An analytical model such as the platoon dispersion model is used to govern the movement of a vehicle platoon along a road link. A macroscopic simulation is deterministic by nature and is useful for network design and optimisation.*

***Hybrid simulation - t**his technique combines a detailed microscopic simulation of some key components of a model (e.g. intersection operations) with analytical models (e.g. speed-flow relationships for traffic assignment). This technique is sometimes known as mesoscopic simulation and provides more detail to what is normally as assignment-only model. It is also possible to interface a microsimulation model with a real-time signal control system such as SCATS.*

2.7 Delay and Journey Time

Intersection and transportation network performance is assessed primarily using the concept of delay. The Austroads Guide to Traffic Engineering Practice, which is widely used in New Zealand, defines delay as the "*additional time necessary to complete a trip due to the alignment of the route and/or the presence of other traffic*" (Austroads, 2005).

There are various methods of categorising where delay arises from, the most simple being broken down into geometric delay and queuing (or control) delay. Geometric delay arises from the physical form of the network or intersection and includes the time required to decelerate in order to negotiate the intersection and accelerate back to desired road speed. This can be considered as the delay that would be experienced regardless of the presence of other vehicles. Queuing or control delay is the delay experienced due to interactions with other vehicles and the road environment. This delay includes the time taken to stop or slow in order to yield priority to another vehicle, to stop or slow for a traffic signal or to join and leave a queue.

2.8 Queuing

Analysis of queuing in transportation networks and systems can be a complex area of theories and methodology. In microsimulation models however, the assessment and comparison of queuing is a simple matter of recording at specified time intervals how many vehicles are queued in specified lanes. When a vehicle is considered as queued and is dictated by user-defined parameters that can include vehicle speed dropping below a certain level and/or the gap between vehicles meeting certain criteria (SIAS, 2005).

2.9 Paramics and Other Modelling Considerations

2.9.1 Description

Paramics is a suite of microscopic simulation transportation modelling software. It was developed by Quadstone and SIAS Limited in the United Kingdom and commercially released in 1998. The two companies have since parted ways and there are Q-Paramics and S-Paramics versions of the software available. This thesis will use S-Paramics, referred to hereon in as Paramics.

Paramics evaluates the actions of every individual vehicle in a road network at sub-second intervals. Each vehicle endeavours to find the best route to its destination as it interacts with other vehicles in the model and the road environment including priority intersections and traffic signal systems.

The movement of vehicles in Paramics is governed by three sophisticated and interacting models that control vehicle following, gap acceptance and lane changing. It also incorporates vehicle dynamics such as acceleration and deceleration and driver aggression and awareness (SIAS, 2005). Examples of the Paramics interface are shown as Figure 2-2 and Figure 2-3.

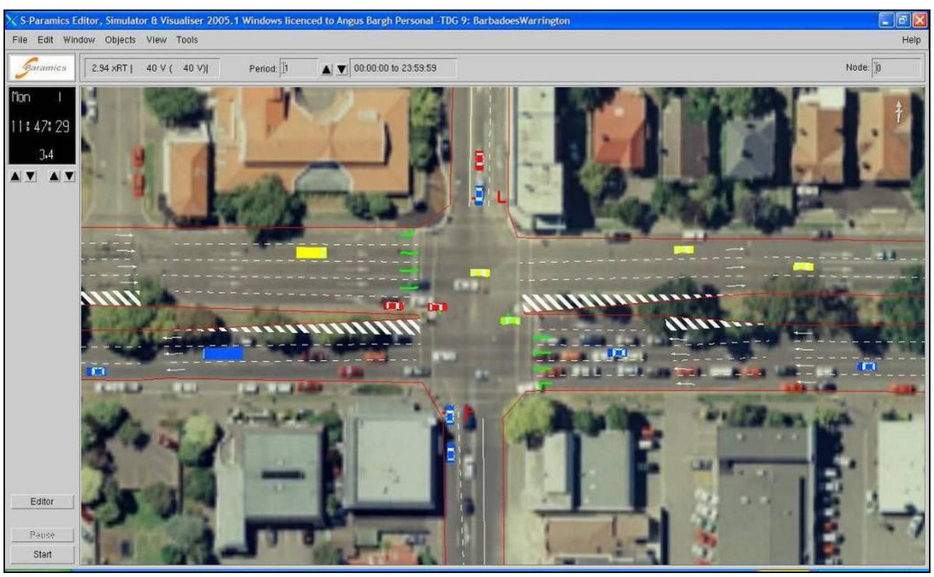


Figure 2-2 - Paramics Interface (Two Dimensional View)

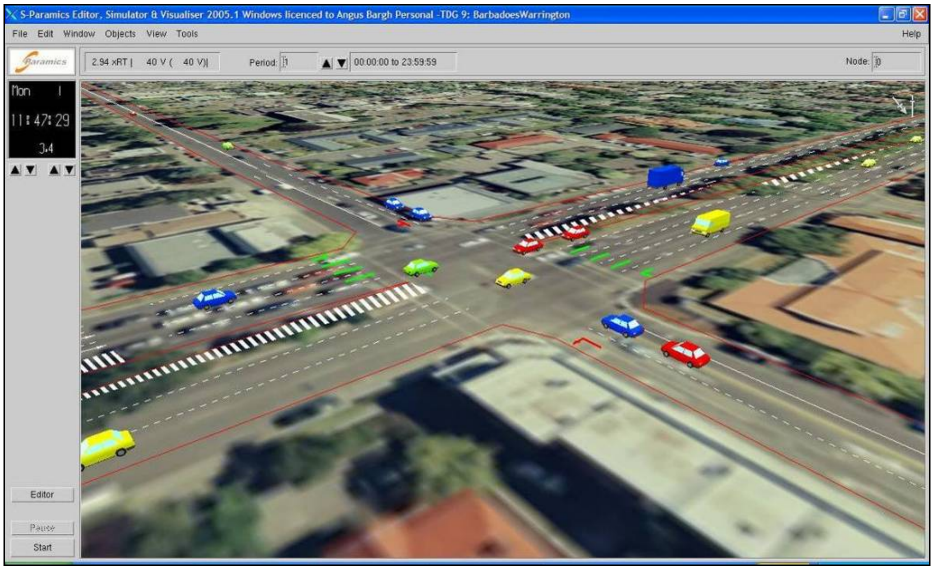
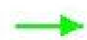


Figure 2-3 - Paramics Interface (Three Dimensional View)

2.9.2 Intersection Modelling

Paramics models intersection priorities using four levels of priority. These are described below and shown with their Paramics notation:

- Major – the movement is completely unopposed 
- Medium – the movement is opposed by one stream of traffic 
- Minor – the movement is opposed by more than one stream of traffic 
- Barred – the movement is not allowed

Some examples of how intersections are coded using these priorities under the existing and changed rules are shown in the following Figures. Figure 2-4 shows the coding of a three-arm priority intersection.

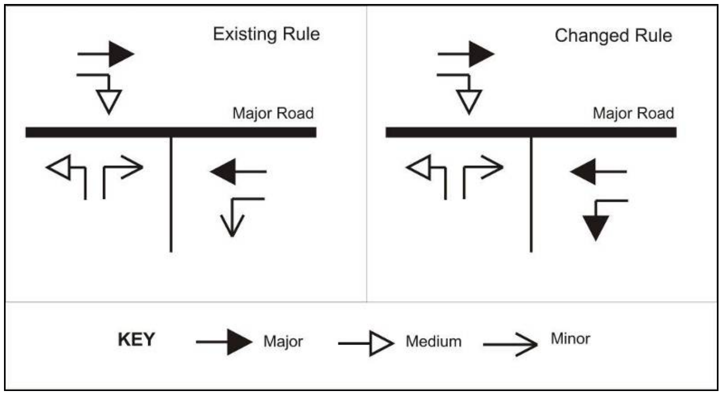


Figure 2-4 – Paramics Coding (Three-Arm Priority)

It is noted that the left turn off the major road is coded as minor even though it is opposed by only one stream of traffic, the right turn off the major road. It is coded as minor so that it gives way to this right turn which is coded as medium. Under the changed rule this movement is unopposed and therefore coded as major. This coding is used for give way and Stop controlled intersections. To model the difference between give way ands stop control, any movements that are on a stop sign have a 'link stop time' of 1 second applied. This means all vehicles making those movements have to stop for 1 second before leaving the end of the stop-controlled link. This also applies at four-arm priority intersections, the coding of which is shown in Figure 2-5.

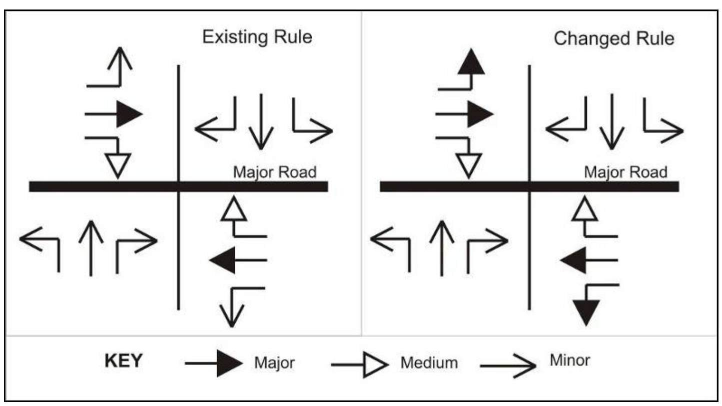


Figure 2-5 – Paramics Coding (Four-Arm Priority)

Near side priority as applies in New Zealand creates two issues at four-arm priority intersections in Paramics. The first issue is that left turn movement off the major road have minor priority which is the same as all the side road movements. This can give rise to situations where a vehicle travelling straight through the intersection from the minor road makes their movement at the same time or before a vehicle from the major road turns left into the same road. In reality the minor vehicle would wait. The effect of this is that Paramics may over estimate the capacity of these movements.

The second issue is that all the side road movement have minor priority and therefore Paramics cannot model that the left turn from one approach is required to yield priority to the right turn from the opposite approach. In Paramics when opposing movements are on the same priority level, either major or minor, they effectively take turns. In a simple situation with no other traffic where left and right turning vehicles are waiting to enter the same major road, one left turner would go, then a right turner would go and so on. In Paramics language, the vehicles look at the stopline of the movement that is opposing them, as the vehicle on one approach moves off and starts its turn the stopline becomes clear so an opposing vehicle goes and the cycle repeats (personal communication B. Wilmshurst, 23 January 2008).

Although this is an area where Paramics does not strictly model the priority rules, microsimulation models are not usually used in situations were the interaction of minor road left and right turners is a crucial element of network modelling. It would be very rare for a Paramics model of a network to be at all reliant on the representation of a stop-controlled four-leg intersection.

Signalised intersections are coded in the same manner with unopposed movements coded as major. Movements where priority rules apply are coded with combinations of the coding shown above for priority intersections.

Two intersections that are investigated in this research feature left turn lanes that are give way controlled. These intersections (with their intersection reference number that is introduced in Section 4 of this report shown in brackets) are Matipo Street/Riccarton Road (Intersection 8), Blenheim Road/Matipo Street (Intersection 7), and Marshland Road/The Palms (Intersection 3). The give way controlled left turn at Matipo Street/Riccarton Road is shown in Figure 2-6. A similar arrangement exists at Marshland Road/The Palms and at Blenheim Road/Matipo Street.

Figure 2-6 – Give Way Left Turn at Matipo Street/Riccarton Road (Intersection 8)

In Paramics these give way controlled left turn lanes are modelled as a separate intersection from the main intersection. The coding that is used under the existing and changed rule is shown as Figure 2-7.

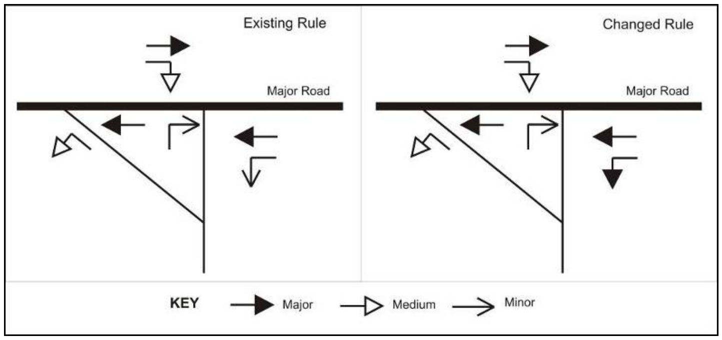


Figure 2-7 – Paramics Coding (Give Way Controlled Left Turn at Traffic Signals)

The give way controlled left turn is modelled as a separate priority intersection at which the left turning traffic gives way to all other traffic on the link it is joining. Therefore it does not directly give way to the opposing right turn as opposing right turn traffic becomes like all other vehicles on the link the left turn slip lane is joining. As illustrated in Figure 2-7, the coding of the separate give way intersection does not change under a rule change to near side priority. At three-arm intersections this is not relevant as there is no opposing right turn. However in the example of Blenheim Road/Matipo Street it means there is not a direct intersection between left and right turns when the left turn is give way controlled.

2.9.3 The New Zealand Left Turn Command Line

Paramics contains an option, known as the New Zealand left turn command line, to specifically model the New Zealand left turn rule. When this command line is applied to a Paramics model network all left turning vehicles in the model will give way to opposing right turning vehicles unless the right turning vehicle becomes opposed by an oncoming through vehicle, in which case the left turning vehicle will undertake the turn as if unopposed. This essentially models a left turning driver looking behind them to see if there is a through vehicle that will shield their turn (personal communication, B. Wilmshurst 12 August, 2006).

2.9.4 Outputs

Paramics can produce an abundance of statistical outputs about the behaviour of every individual vehicle in the model. For this thesis two outputs will be analysed, journey time and queue length. Journey times are collected in Paramics using journey paths. A journey path is set in the model and the time taken for every vehicle to complete that path is recorded. In this research paths have been set for all movements through the intersection.

Queuing activity is collected in a similar way. A queue path has been set on every approach to the intersection. Queue recognition criteria are set to determine when a vehicle is considered to be queued. The Paramics default criteria has been adopted. Under these criteria a vehicle is queued if its speed drops below 7.2 km/h and the gap to the next vehicle is less than 10m. The vehicle is no longer queued when either its speed increases to 10.8 km/h or the gap to the next vehicle exceeds 15 m. Queuing statistics are reported by lane in two-minute time intervals. In this thesis the measure that has been used is the maximum queue recorded in each time interval.

2.9.5 Microsimulation versus Analytical Modelling (Paramics versus SIDRA)

The isolated intersection analysis package SIDRA was first released by ARRB Transport Research Limited in 1984. It uses analytical traffic models coupled with an iterative approximation method to provide estimates of capacity and performance statistics such as delay and queue length (Akcelik and Besley, 1999).

Paramics is one type of microsimulation software that uses various rules for the movement of vehicles in a system. There is ongoing debate about the merits of each type of analysis tool. *Microsimulation is still an evolving science* (Austroads, 2006). Although microsimulation has become an accepted transportation planning tool in recent years (Austroads, 2006), it is yet to establish the same sort of credibility as more traditional traffic models. Identified weaknesses of microsimulation models (Akcelik, 2007) include:

- Substantial data requirements
- Results easily influenced by the modeller
- Calibration difficulties
- Benchmarking and comparisons can be difficult
- The realistic graphical representations can give unrealistic expectations of accuracy that isn't there

In New Zealand traffic engineering practice microscopic simulation is widely used and accepted as an analysis tool. It offers some advantages including superior graphical representation and the ability to deal with some complex situations and larger networks where intersections interact, that analytical models cannot. However, data requirements are greater than analytical models and like many computer software packages, the quality of the output is greatly dependent on the quality of the input and the appropriate use of the software.

In New Zealand a Modelling User Group (MUG) was established in 2006 as a sub-group of the IPENZ Transportation Group. The MUG represents micro-simulation and macro-simulation traffic and transportation modelling practitioners and one of their purposes is to promote traffic and transportation modelling industry standards (Baseplus Limited, 2008).

In SIDRA intersection priorities are specified by identifying which movements are opposed by which other movements and then specifying the parameters that govern these turns such as critical gap and follow-on headway. In the case of the New Zealand left turn rule, a left turn into a side road would be specified as being opposed by a right turn into the same road and in this right turn would be opposed by the oncoming through movement (Akcelik and Besley, 1999). How Paramics models intersection priorities was described in Section 2.9.

Both micro-simulation and analytical models are widely used in New Zealand and both have their advantages and disadvantages, which are actively promoted and highlighted by their respective developers. Both have applications where the data requirements, purpose of analysis, required outputs and available timeframes and project budgets make them the most appropriate tool.

Paramics has become increasingly popular in New Zealand as the main analysis tool used by City Councils to manage and plan their road networks. Christchurch, Queenstown, Palmerston North and Napier are some of the cities to have Paramics models for this purpose (personal communication, A.Bargh, 10 October 2007).

SIDRA was used in the analysis undertaken by Hughes (1997) and it was noted that SIDRA was not the ideal tool for comparing the two rules. The main reason for this was that SIDRA is based on mathematical model using specified gap acceptance parameters. The researchers felt that these gap acceptance parameters would vary under each rule as the difficultly of each manoeuvre is different under each rule. Gap acceptance parameters can be manually set in SIDRA however no data was available to assess what these parameters might be before and after a rule change. Therefore some assumption could have been made and the gap acceptance parameters modified, but this would in effect create a comparison between two user defined sets of parameters. SIDRA, like any other analytical traffic model, is not designed to predict how drivers will behave. Other issues the researchers identified included the inability of SIDRA to model some on-street behaviour, such as vehicles using available road width to pass a vehicle that is waiting to turn when a formal lane is not marked. Some drivers may do this, some may not. SIDRA cannot represent situation where sometimes an approach operates as single lane and sometimes multi-lane (personal communication, T. Hughes 22 January 2008).

Paramics does not offer a solution to these issues. It also uses gap acceptance models with varying driver aggression and awareness. These settings can be altered however there is no data available on conditions before and after a rule change on which to base any adjustments. Rule systems aside, gap acceptance is inherently difficult to measure anyway, being very site specific and varying greatly between drivers and within the same driver from one day to the next (personal communication, T. Penny 18 January 2008).

This thesis will use Paramics and some case study intersections to provide a new type of analysis and comparison of the two rules. Whilst it is recognised that gap acceptance parameters may be affected by which rule is in place, these parameters will be kept constant in this research. This will allow a like with like comparison that isolates the effects of near and far side priority. The research will not resolve the gap acceptance and on-street behaviour issues identified by Hughes however it will further investigate the rule using a new traffic modelling approach and one that allows for the stochastic nature of traffic networks. It will also lead to conclusions about the ability of Paramics to compare the two rules, in the same way the SIDRA research did about that package.

Whilst Paramics can offer advantages over many traditional traffic analysis techniques, the results of this thesis should be read and interpreted in the knowledge that every traffic modelling technique and software has its limitations. Paramics, like all microscopic simulation models is a simplification of reality (Austroads, 2006).

2.10 Implications for this Thesis

The literature review has raised the following issues or statements that can be investigated further by this thesis:

- Does the current rule reduce or minimise right turn delays?
- If the rule is changed will right turn delays increase?
- Will any change be matched by a decrease in delay for left turn movements?
- Is there any difference in the overall performance of each rule?
- Will vehicles use the left lane multi-lane roads more if the rule is changed?
- Does the rule change to near side priority have different impacts on different intersection types and different volumes?
- Are intersections less likely to block under the changed rule?
- In a network situation will vehicles re-route and, for example avoid difficult right turns such that the overall effect on the network is negligible?
- Are there any design considerations arising from the rule change to near side priority? For example, will some priority intersections required signalisation earlier as a result of a rule change to near side priority? Will some right turn bays need to be introduced or extended? Will right turn phases be required?

This thesis will use Paramics software to further investigate these issues and the overall difference between the two rules. The results will be compared against the findings of earlier research and will give an indication of whether there are any significant differences between the rules.

3 Methodology

3.1 Overview

Ten Christchurch intersections have been selected for analysis using Paramics microscopic simulation. The locations of the intersections are shown as Figure 3-1. Each intersection is described in detail in Section 4 of this thesis.

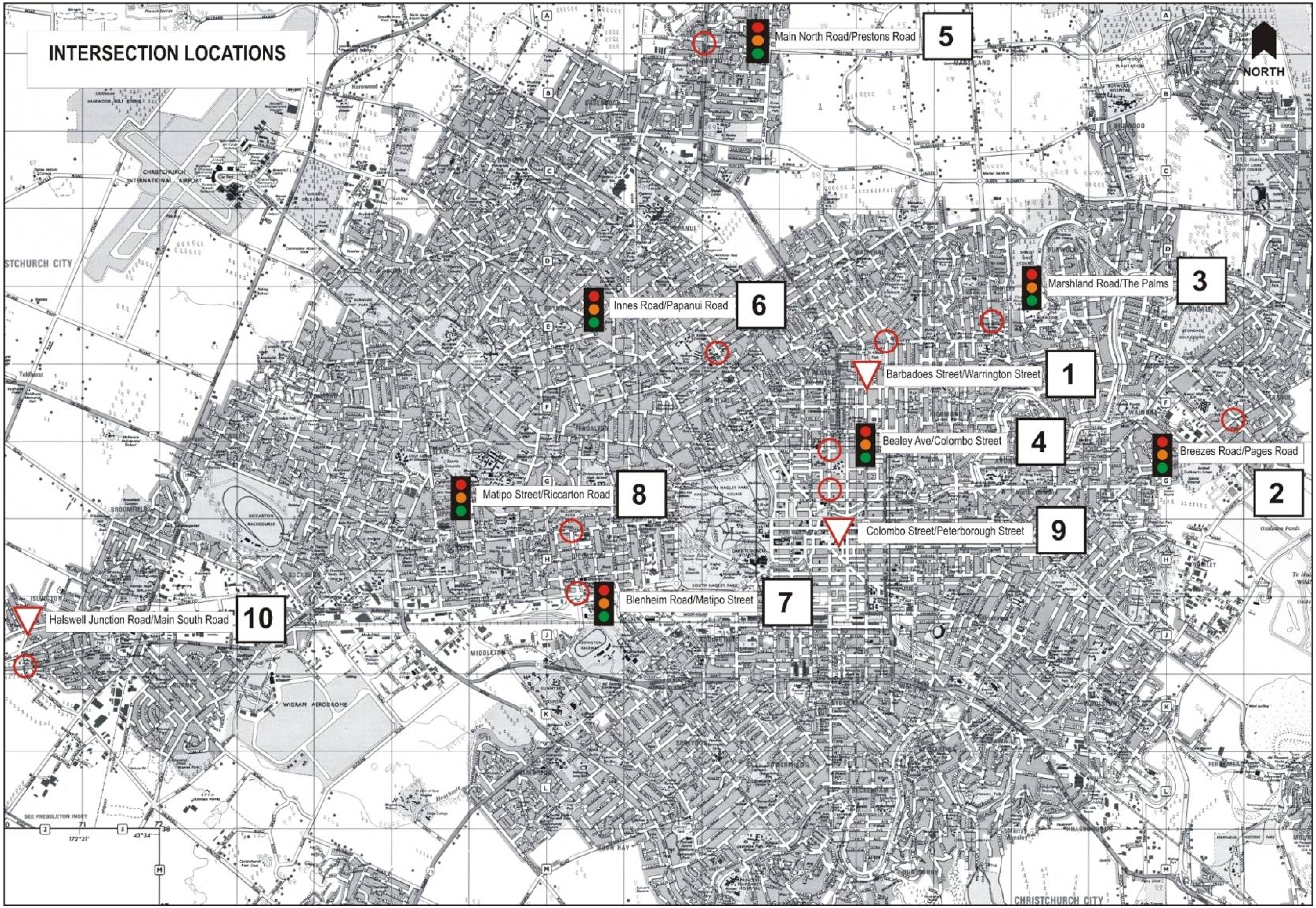


Figure 3-1 – Intersection Locations

The traffic volumes through each intersection were manually counted and queue length observations were made for the purpose of comparing observed and modelled intersection operation. Each intersection was surveyed for 90 minutes generally during the weekday afternoon/evening peak period. The Paramics models will represent this 90 minute period and statistics will be collected for the middle 60 minutes.

The intersections have been coded in Paramics using aerial photographs, signal plans and on-site observations to ensure accurate representation.

3.2 Data Collection

The ten intersections were surveyed during the period September to November 2006. A 90 minute survey was undertaken by a group of observers recording vehicle movements. The surveys were undertaken during the mid to late afternoon. Some example data collection sheets are presented in Appendix A1. Summarised survey results for all intersections are presented in Appendices A3 to A12.

As the pattern and scale of traffic volumes through the intersection is clearly related to the type and layout of the intersection, the purpose of the traffic volume counts was to provide a realistic starting point for analysis. Traffic volumes were recorded in 15 minute intervals and disaggregated by light and heavy vehicles types.

3.3 Tested Traffic Volume Combinations

3.3.1 Method 1

Method 1 (M1) takes all movements at the intersection and applies multiplication factors of 75%, 100%, 125%, 150% and 175%. This method of varying volumes has been selected to investigate whether the total intersection volume has any effect on the results. A graphical representation of this sampling method is shown as Figure 3-2.

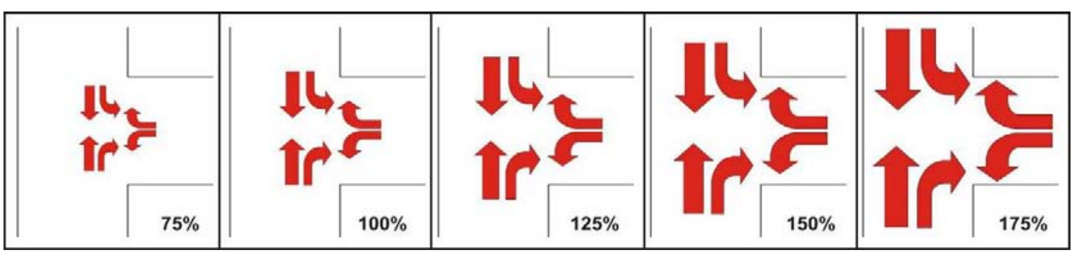


Figure 3-2 – Sampling M1 Diagram

3.3.2 Method 2

Method 2 (M2) keeps the overall volume through the intersection constant and varies the proportion of right turning traffic. In the case of three-arm priority or signalised intersections the major road right turn volume is factored. For four-arm priority intersections the two major road right turn volumes are factored. For four-arm signalised intersections all four right turn volumes are factored. The factors applied are 50%, 100%, 150%, 200% and 300%.

All other movements at the intersection are factored down to retain their original proportions of the volume remaining after the right turn volumes have been removed. This method of varying volumes has been selected to investigate whether the volume of right turners has any impact on the results. A graphical representation of this sampling method is shown as Figure 3-3.

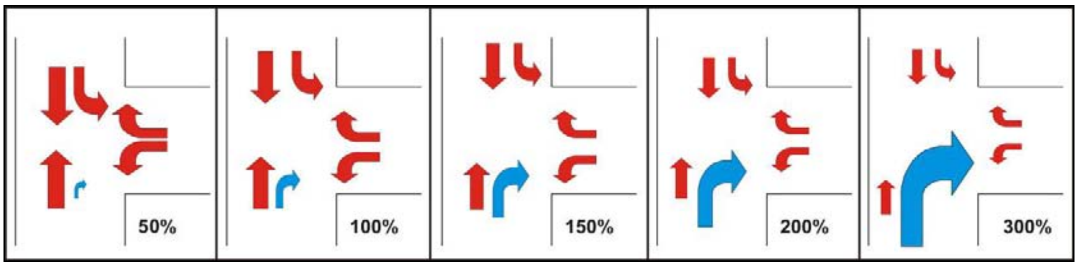


Figure 3-3 – Sampling M2 Diagram

3.4 Modelled Signal Operation

For the seven signalised intersections, signal times were obtained from Christchurch City Council for a full 24 hour period on a weekday during September/October 2006. The observed signal timings were averaged for the time period corresponding to the manual turning count survey of the intersection and applied in the model. These average timings were used as a starting point in the Paramics model of the intersection using 100% of the observed traffic volumes. As the surveyed traffic count day and the observed signal timing day were not exactly the same, the model was then observed and the signal timings were adjusted if necessary to visually optimise the signal operation and give realistic operation. The observed and modelled signal timings for each intersection are summarised in Appendices A3 to A12.

The observed signal timings (which represent the 100% scenarios) are unchanged for all other tested scenarios. This was done to completely isolate the effect of the rule change to near side priority and to permit a consistent comparison between the two rules. This also enables the question of whether signal timings would or should change following a rule change to near side priority to be answered.

3.5 Statistical Analysis

3.5.1 Journey Time Performance Indicators

This thesis will assess journey times by collecting journey times for every modelled vehicle making each movement through an intersection.

A comparison will then be made between the journey times for each movement under the existing rule and the changed rule. It is this difference which is of interest. For simplicity in this research no attempt is made to define delay. The difference between the two journey times can however be considered as representing a change in delay since whatever method was adopted for determining delay would be the same for both rules and any change in journey time would translate directly to a change in delay.

The two outputs that will be analysed and compared are the journey time for each movement through the intersection and the queue length on each approach to the intersection. Journey times provide a means of comparing efficiency and queue lengths allow a comparison of the design implications of each rule. The statistical measures that will be used to describe journey times are:

- Mean
- 15th Percentile
- 85th Percentile

These statistics will describe typical journey times and also the spread of journey times. Figure 3-4 below shows these statistics overlaid on a distribution of right turn journey times obtained from ten runs of the Intersection 1 model, Barbadoes Street/Warrington Street.

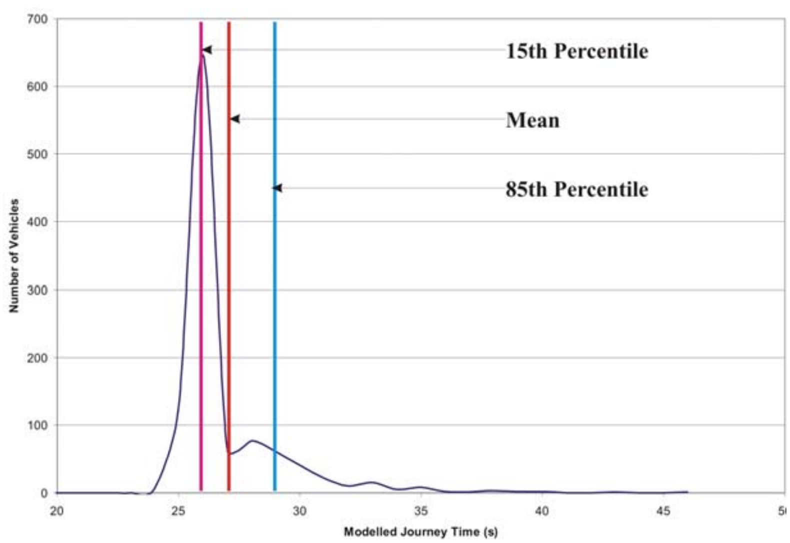


Figure 3-4 - Right Turn Journey Time Analysis (Intersection 1, 75% of Surveyed Volumes)

Figure 3-5 shows the same statistics for the same intersection with the volumes increased to 200% of the surveyed volumes.

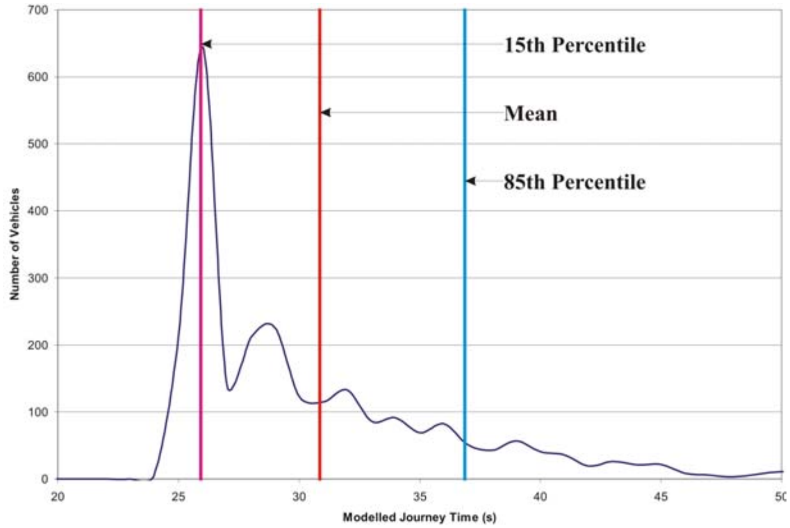


Figure 3-5 - Right Turn Journey Statistical Analysis (Intersection 1, 200% of Surveyed Volumes)

It is evident that with the increase in total intersection volume both the mean value increases and the spread of journey times, described by the 15th and 85th percentiles increases. These figures illustrate that the selected journey time statistics will adequately describe the differences between journey times under various scenarios. The median value could have also been presented but for clarity in presentation only the mean value is presented as this is the statistic most commonly used in professional traffic engineering practice to describe intersection performance.

The standard graph for presenting the results is shown as Figure 3-6 using the generic colouring of red (the darker colour if viewed in grey scale) for the existing rule and blue (the lighter colour if viewed in grey scale) for the changed rule.

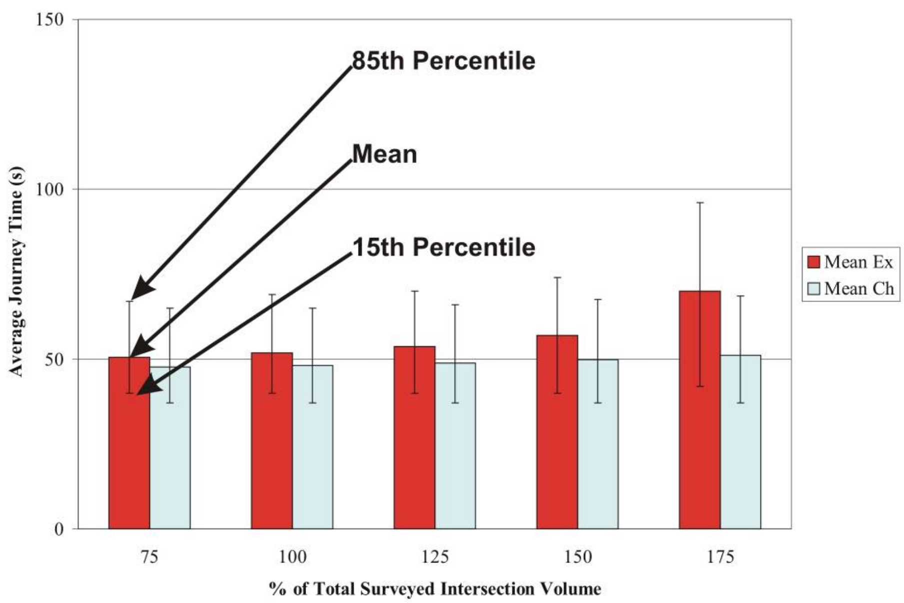


Figure 3-6 – Journey Time Example Graph

3.5.2 Queue Length Performance Indicators

The statistics selected to describe the queue lengths for each scenario are the average (mean) and maximum queue length, measured in number of vehicles. These are both averaged over ten model runs.

Queue lengths are commonly reported as 85th or 95th percentile values particularly in analytical software packages such as SIDRA. In microscopic simulation a series of observations are made in specified time intervals. Paramics does not report percentile queue lengths in the manner that is commonly used in analytical models. Calculation of percentiles would require collection of queue data for very small time intervals and the sheer volume of data for every lane of every intersection in every model run for such time steps would be substantial and exceed what could be manipulated by spreadsheet analysis. As the overall purpose of this thesis a comparison between two rules, the average queue over the modelled 60 minute period and the maximum queue recorded in this period have been selected. It is noted that Paramics records the maximum queue in any time step, not a 'snapshot' queue and therefore there is no potential for the queue observation to miss maximums, for example if it were to coincide with the end of various green times when a queue has dissipated.

The standard graph for presenting the results is shown as Figure 3-7 using the generic colouring of red for the existing rule and blue for the changed rule, or dark and light respectively if viewed in grey scale.

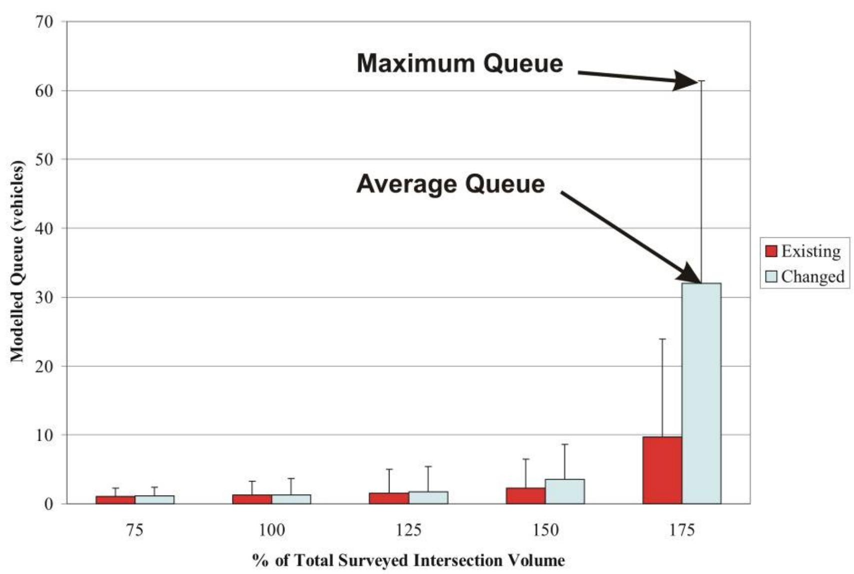


Figure 3-7 – Queue Length Example Graph

3.5.3 Convergence

Microsimulation models are stochastic. This means that '…*each time the model is run a unique stream of random numbers is used to govern the events in that run.'* (Seamen, 2006). The output from each model run is different and it is therefore necessary to take an average across multiple model runs to gain a stable and representative output.

Some testing was conducted to establish the number of simulation runs that would produce a stable average for journey time. Prior to the individual intersection testing four intersections were tested at their surveyed traffic volumes and with these volumes factored up by 150%. This analysis indicated that ten model runs was sufficient to obtain a stable average value. Ten runs were therefore used for the individual intersection analyses. The results were then checked for stability to confirm the appropriateness of ten runs. The checks were undertaken on the Method 1 175% scenario for each intersection since this was the highest volume scenario. The following section presents the full results for Intersection 1- Barbadoes Street/Warrington Street. The equivalent of Figure 3-8 and Figure 3-9 for the other nine intersections are presented in Appendix A2.

Figure 3-8 and Figure 3-9 present the average overall journey time for all movements through Intersection 1 – Barbadoes Street/Warrington Street for the Method 1 175% traffic volumes by model run and cumulative average.

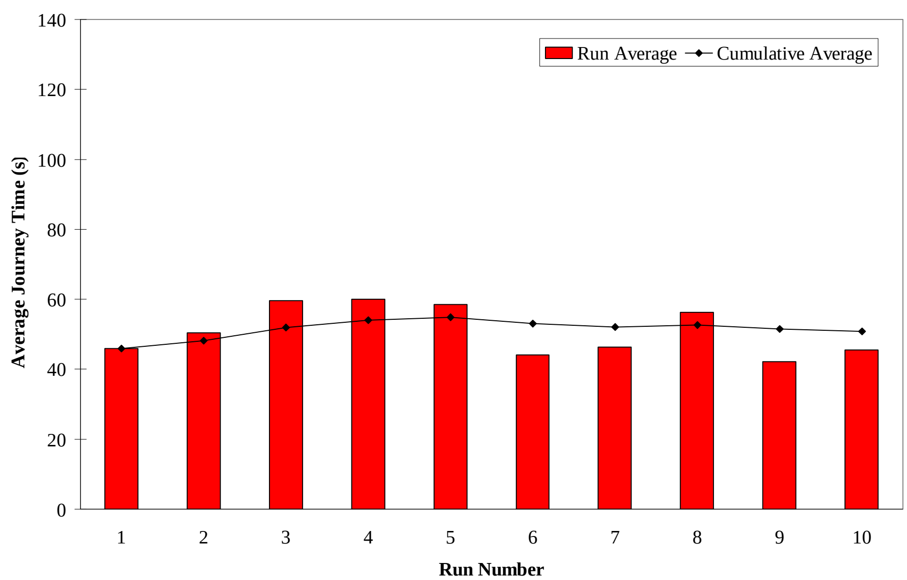


Figure 3-8 - Journey Time Convergence All Movements (Intersection 1, M1, 175, Ex)

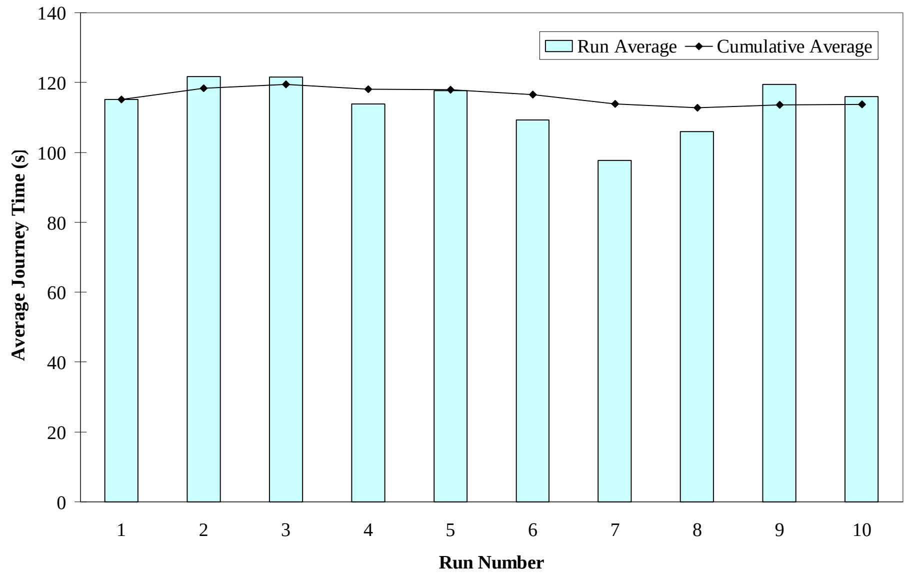


Figure 3-9 - Journey Time Convergence All Movements (Intersection 1, M1, 175, Ch)

Figure 3-10 and Figure 3-11 show the average journey time calculated after each model run at Intersection 1 – Barbadoes Street/Warrington Street for the Method 1 175% traffic volumes, for the existing and changed rule respectively. As described in the Glossary the key for each movement is a two-letter code with the first letter being N, E, S or W for North, South, East or West and the second letter describing the movement as left (L), through (T) or right (R).

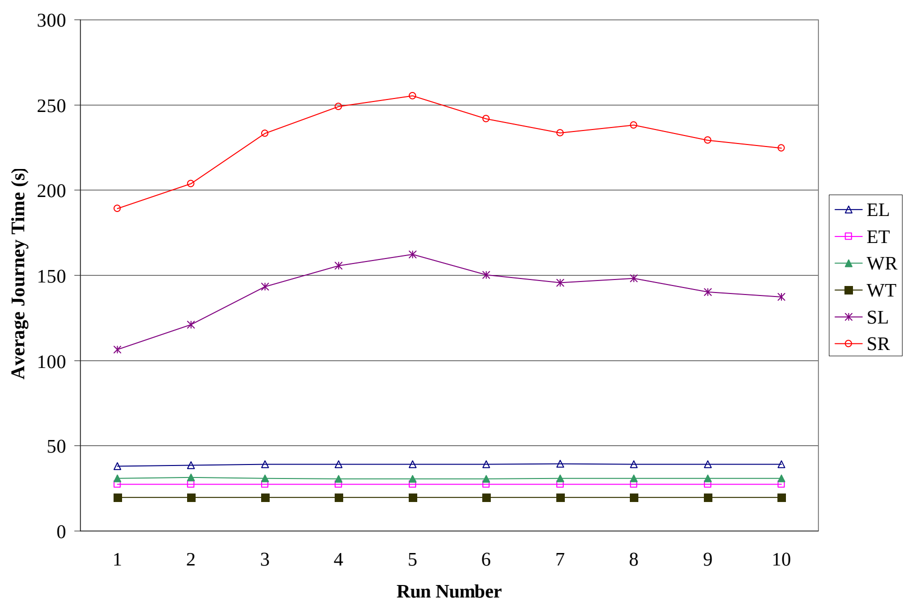


Figure 3-10 - Journey Time Convergence by Movement (Intersection 1, M1, 175, Ex)

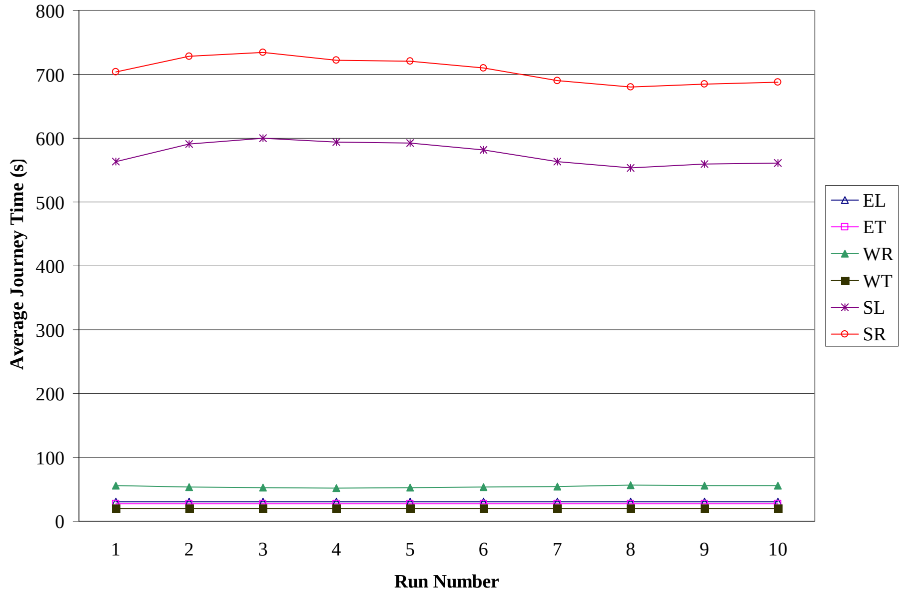


Figure 3-11 - Journey Time Convergence by Movement (Intersection 1, M1, 175, Ch)

Figure 3-8 to Figure 3-11 indicate that there is very little change in average journey time for any movement after ten runs. Therefore this number of model runs is considered an appropriate number from which to gain stable and representative statistics for journey time.

Some analysis was also undertaken on the confidence intervals obtained after each model run. Table 3-1 and Table 3-2 present the 95% confidence limits obtained by considering between two and ten model runs for the Barbadoes Street/Warrington Street intersection under the Method 1, 175% scenario for the existing and changed rules respectively.

Table 3-1 – Journey Time (s) Confidence Intervals (Intersection 1, M1, 175, Ex)

Runs Considered	Run Average	Average of Considered Runs	95% Confidence Lower Bound	95% Confidence Upper Bound	Confidence Interval as a % of Average
1	46	46	-	-	-
2	50	48	44	53	9.2%
3	60	52	44	60	15.2%
4	60	54	47	61	12.6%
5	58	55	49	60	10.2%
6	44	53	47	59	10.8%
7	46	52	47	57	10.0%
8	56	53	48	57	8.8%
9	42	51	47	56	9.1%
10	45	51	47	55	8.6%

Table 3-2 – Journey Time (s) Confidence Intervals (Intersection 1, M1, 175, Ch)

Runs Considered	Run Average	Average of Considered Runs	95% Confidence Lower Bound	95% Confidence Upper Bound	Confidence Interval as a % of Average
1	115	115	-	-	-
2	122	118	112	125	5.5%
3	122	119	115	124	3.6%
4	114	118	114	122	3.5%
5	118	118	115	121	2.7%
6	109	117	113	120	3.3%
7	98	114	108	120	5.4%
8	106	113	107	119	5.1%
9	119	114	108	119	4.6%
10	116	114	109	119	4.1%

The calculated confidence intervals are shown graphically in Figure 3-12.

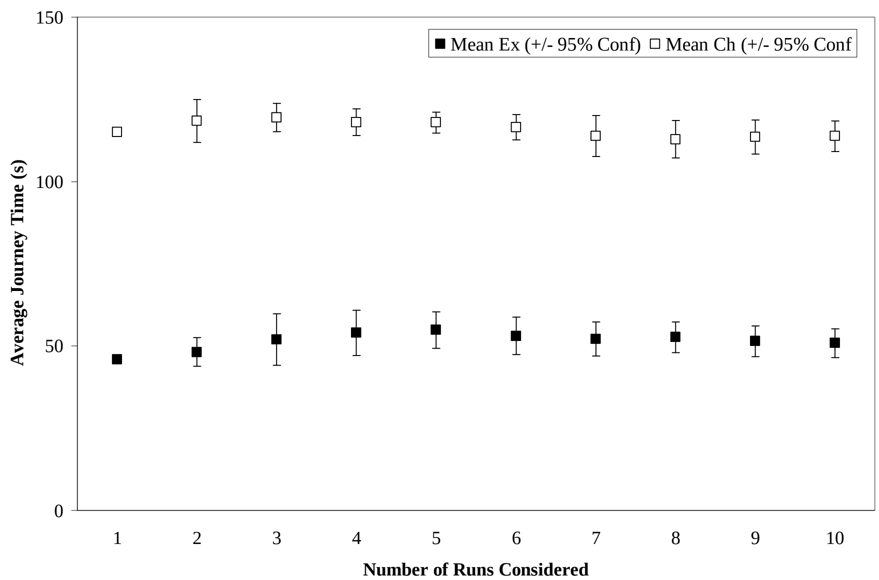


Figure 3-12 – Confidence Intervals by Number of Runs Considered

The graph shows that the confidence interval narrows as the number of runs considered increases. The overall difference from two runs to ten runs is relatively small which reflects the stability of the models. There is very little change in the confidence interval after around eight runs, which indicates that the use of ten model runs is appropriate.

The importance of confidence intervals in microsimulation models relates to the confidence with which 'average' results from one model can be compares to 'average' results from another. In the case of this thesis this comparison is between the existing and changed rules.

Figure 3-13 shows a comparison between the modelled average journey time from Barbadoes Street/Warrington Street under the existing and changed rules.

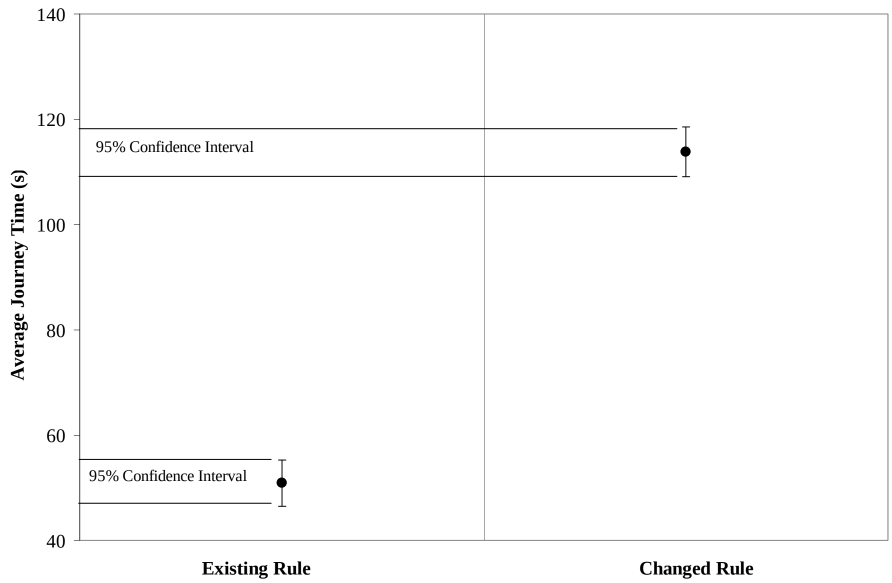


Figure 3-13 – Confidence Intervals Existing and Changed Rules, after 10 Runs

Figure 3-13 illustrates that the modelled average journey times and the associated 95% confidence intervals are well separated. These results could be reported to a 95% level of confidence as 51 s/veh $\pm$ 4 s/veh for the existing rule and 114 s/veh $\pm$ 5 s/veh for the changed rule.

The conclusion from this analysis is that at the greatest level of traffic volumes (under the Method 1, 175% scenario) the modelled journey times from the intersection of Barbadoes Street/Warrington Street have a 95% confidence level of less than $\pm$ 10%. Therefore any differences that are greater than this between the two rules can be considered as statistically significant. Differences that fall within this $\pm$ 10% range should be interpreted as less significant.

4 Case Study Intersections

4.1 Intersection 1: Barbadoes Street/Warrington Street

4.1.1 Intersection Layout

The three-arm give way controlled intersection of Warrington Street and Barbadoes Street is located north of the Christchurch central business district (CBD). Barbadoes Street is a classified as a collector road with the road hierarchy of the Christchurch City District Plan ("City Plan") and has a daily traffic volume of 7,000 vpd. Warrington Street is a minor arterial carrying 10,000 vpd. Warrington Street forms the major road and features dedicated left and right turning lanes. Barbadoes Street is controlled by give way signs and has effectively a two-lane approach allowing left and right turning vehicles to queue side by side. The surrounding land uses are predominantly commercial including a small local shopping centre and other suburban retail activities. The intersection is shown in Figure 4-1. Photographs of each approach are presented in Appendix A3.

Figure 4-1 – Warrington Street/Barbadoes Street Aerial Photograph

4.1.2 Intersection Volumes

The intersection was manually surveyed on Tuesday 26 September 2006 from 3:00pm to 4:30pm. The observed turning movements during the middle one-hour period from 3:15pm to 4:15pm are shown in Figure 4-2. Full survey data is presented in Appendix A3.

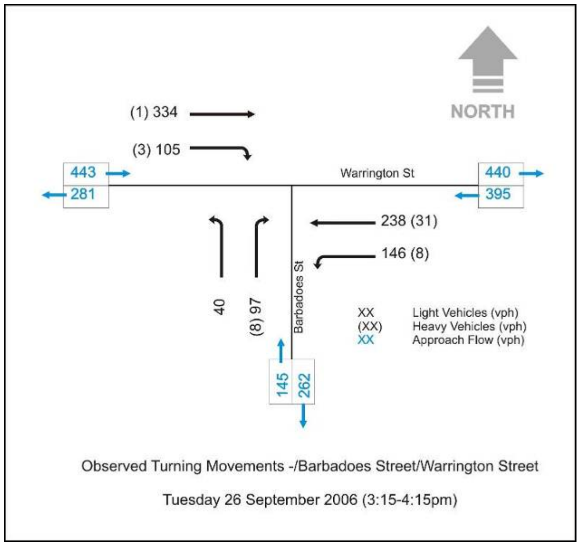


Figure 4-2 –Barbadoes Street/Warrington Street Turning Movements

4.2 Intersection 2: Breezes Road/Pages Road

4.2.1 Intersection Layout

The four-arm signalised intersection of Pages Road and Breezes Road is located in eastern Christchurch. The intersection is surrounded by predominantly commercial land uses including a petrol station. Pages Road is a major arterial carrying 14,000 vehicles per day (vpd). Breezes Road carries some 9,500 vpd and is classified as a collector route north of Pages Road and a minor arterial to the south. It is noted that the Breezes Road south approach has been upgraded since the aerial photograph was taken. The upgraded approach which now includes separate left, through and right turn lanes has been modelled. The intersection is shown in Figure 4-3. Photographs of each approach are presented in Appendix A4.

Figure 4-3 –Breezes Road/Pages Road Aerial Photograph

4.2.2 Intersection Volumes

The intersection was manually surveyed on Monday 2 October 2006 from 4:30pm to 6:00pm. The observed turning movements during the middle one-hour period 4:45pm to 5:45pm are shown in Figure 4-4 below. Full survey data is presented in Appendix A4.

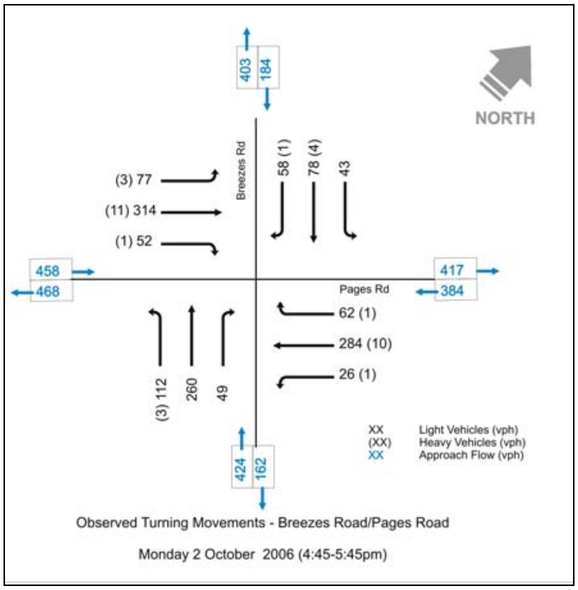


Figure 4-4 - Breezes Road/Pages Road Turning Movements

4.2.3 Traffic Signal Operation

The traffic signal plan for the intersection of Breezes Road/Pages Road is shown in Appendix A4. Again it is noted that the Breezes Road south approach has been upgraded since the signal plan was prepared and an updated version was not available. The intersection operates on a two-phase arrangement. A summary of observed and modelled signal timings is provided in Appendix A4.

4.3 Intersection 3: Marshland Road/The Palms

The three-arm signalised intersection of Marshland Road and The Palms Shopping Centre is located in north-east Christchurch. Marshland Road is a minor arterial carrying around 17,000 vpd. There are separate right and turn lanes provided on Marshland Road. The Palms approach has a signalised right turn lane and a give way controlled left turn. The intersection is shown in Figure 4-5. Photographs of each approach are presented in Appendix A5.

Figure 4-5 - Marshland Road/The Palms Aerial Photograph

The intersection was manually surveyed on Tuesday 7 November 2006. The observed turning movements during the hour 2:45-3:45pm are shown in Figure 4-6 below. Full survey data is presented in Appendix A5.

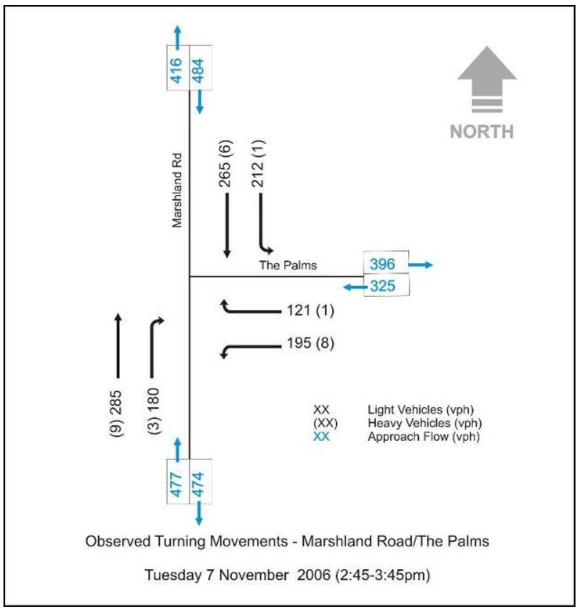


Figure 4-6 - Marshland Road/The Palms Street Turning Movements

4.3.1 Traffic Signal Operation

The traffic signal plan for the Marshland Road/The Palms intersection is shown in Appendix A5. The intersection operates on a three-phase arrangement with the right turn from Marshland Road into The Palms having a dedicated phase. A summary of observed and modelled signal timings is provided in Appendix A5.

4.4 Intersection 4: Bealey Avenue/Colombo Street

The four-arm signalised intersection of Bealey Avenue and Colombo Street is located on the northern boundary of the Christchurch CBD. Bealey Avenue is a major arterial carrying around 31,000 vpd. Colombo Street is a collector route carrying 5,500 vpd. The surrounding land use is a mixture of residential and commercial. The intersection is shown in Figure 4-7. Photographs of each approach are presented in Appendix A6.

Figure 4-7 - Bealey Avenue/Colombo Street Aerial Photograph

The intersection was manually surveyed on Tuesday 14 November 2006. The observed turning movements during the hour 4:45-5:45pm are shown in Figure 4-8 below. Full survey data is presented in Appendix A6.

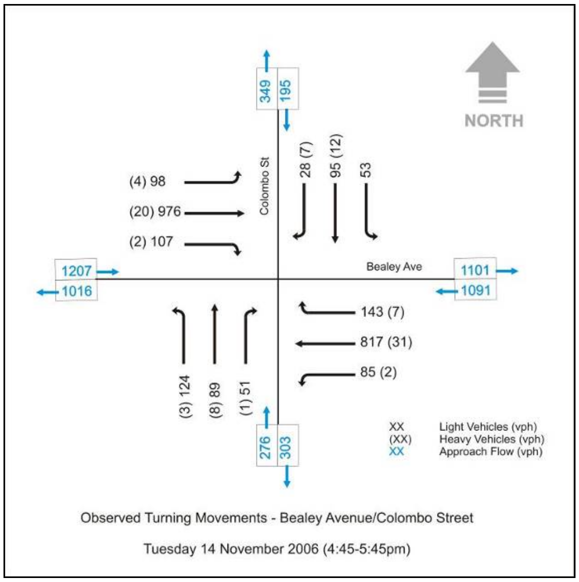


Figure 4-8 - Bealey Avenue/Colombo Street Turning Movements

4.4.1 *Traffic Signal Operation*

The traffic signal plan for the Bealey Avenue/Colombo Street intersection is shown in Appendix A6. The intersection operates on a two-phase arrangement. A summary of observed and modelled signal timings is provided in Appendix A6.

4.5 Intersection 5: Main North Road/Prestons Road

The three-arm signalised intersection of Main North Road (SH74) and Prestons Road is located in northern Christchurch. Main North Road is a major arterial and part of the State Highway network. It carries a daily traffic volume of around 28,500 vpd. Prestons Road is a minor arterial carrying 6,500 vpd. The surrounding land use is generally commercial on the eastern side of Main North Road including a Mobil petrol station and motel/restaurant on each corner. The western side of Main North Road is residential as is the area further east on Prestons Road. The intersection is shown in Figure 4-9. Photographs of each approach are presented in Appendix A7.

Figure 4-9 - Main North Road/Prestons Road Aerial Photograph

The intersection was manually surveyed on Friday 29 September 2006. The observed turning movements during the hour 3:45-4:45pm are shown in Figure 4-10 below. Full survey data is presented in Appendix A7.

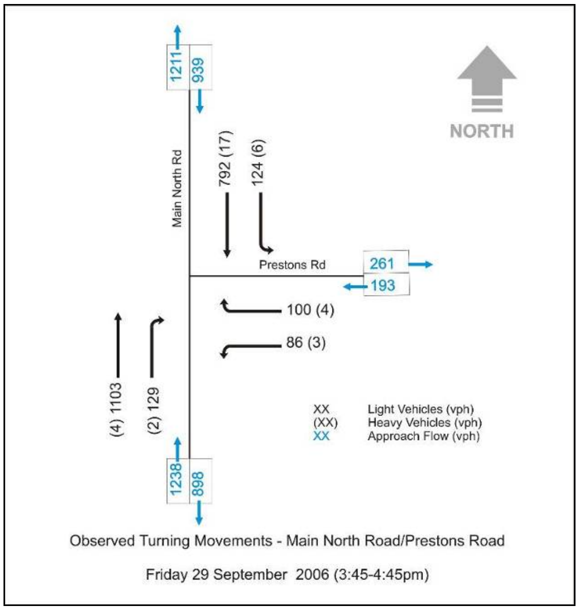


Figure 4-10 - Main North Road/Prestons Road Turning Movements

4.5.1 Traffic Signal Operation

The traffic signal plan for the Main North Road/Prestons Road intersection is shown in Appendix A7. The intersection operates on a three-phase arrangement with the right turn from Main North Road into Prestons Road having a dedicated phase. A summary of observed and modelled signal timings is provided in Appendix A7.

4.6 Intersection 6: Innes Road/Papanui Road

The four-arm signalised intersection of Papanui Road and Innes Road is located in north-inner Christchurch. Papanui Road and Innes Road are both minor arterials carrying 25,000 and 14,500 vpd respectively. The surrounding land use is a mixture of residential and healthcare facilities including eye clinics on two corners. St Georges Hospital and the Merivale commercial area lie to the south. The intersection is shown in Figure 4-11. Photographs of each approach are presented in Appendix A8.

Figure 4-11 - Innes Road/Papanui Road Aerial Photograph

The intersection was manually surveyed on Wednesday 8 November 2006. The observed turning movements during the hour 3:00-4:00pm are shown in Figure 4-12 below. Full survey data is presented in Appendix A8.

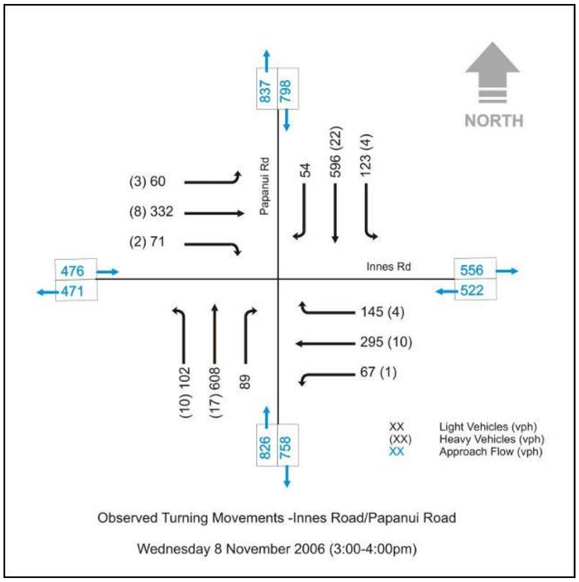


Figure 4-12 – Innes Road/Papanui Road Turning Movements

4.6.1 Traffic Signal Operation

The traffic signal plan for the Innes Road/Papanui Road intersection is shown in Appendix A8. The intersection operates with a single diamond phase arrangement with the right turns from Innes Road having dedicated phases. A summary of observed and modelled signal timings is provided in Appendix A8.

4.7 Intersection 7: Blenheim Road/Matipo Street

The four-arm signalised intersection of Blenheim Road and Matipo Street is located west of the Christchurch CBD. Blenheim Road is a major arterial and carries 36,000 vpd. Matipo Street is a collector road carrying 10,000 vpd. The surrounding land use is generally residential on the northern side and commercial and industrial on the southern side including a service station on the south west corner. The intersection is shown in Figure 4-13. Photographs of each approach are presented in Appendix A9.

Figure 4-13 - Blenheim Road/Matipo Street Aerial Photograph

The intersection was manually surveyed on Tuesday 14 November 2006. The observed turning movements during the hour 2:45-3:45pm are shown in Figure 4-14 below. Full survey data is presented in Appendix A9.

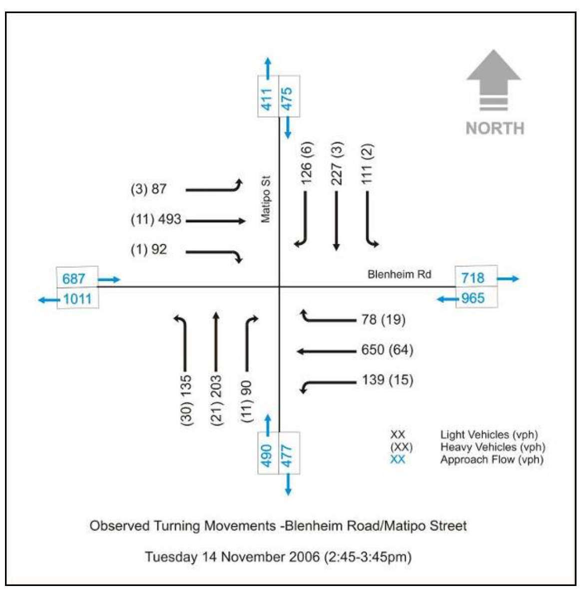


Figure 4-14 – Blenheim Road/Matipo Street Turning Movements

4.7.1 Traffic Signal Operation

The traffic signal plan for the Blenheim Road/Matipo Street intersection is shown in Appendix A9. The intersection operates with a three-phase arrangement with the right turns from Blenheim Road into Matipo Street (North) having a dedicated phase. A summary of observed and modelled signal timings is provided in Appendix A9.

4.8 Intersection 8: Matipo Street/Riccarton Road

The three-arm signalised intersection of Riccarton Road and Matipo Street is located west of the Christchurch CBD. Riccarton Road is a minor arterial carrying 26,000 vpd. Matipo Street is a collector route and carries 14,000 vpd. The surrounding land use is a mixture of commercial, including the Westfield Riccarton shopping complex, and residential. The intersection is shown in Figure 4-15. Photographs of each approach are presented in Appendix A10.

Figure 4-15 - Matipo Street/Riccarton Road Aerial

The intersection was manually surveyed on Wednesday 27 September 2006. The observed turning movements during the hour 3:30pm - 4:30pm are shown in Figure 4-16 below. Full survey data is presented in Appendix A10.

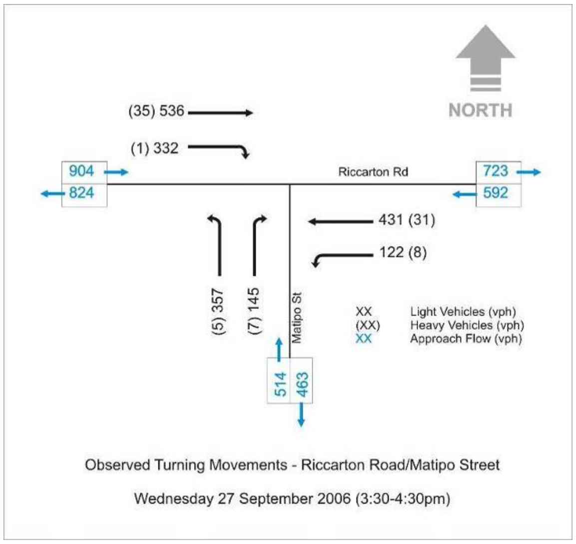


Figure 4-16 - Matipo Street/Riccarton Road Turning Movements

4.8.1 Traffic Signal Operation

The traffic signal plan for the Matipo Street/Riccarton Road intersection is shown in Appendix A10. The intersection operates with a three-phase arrangement with the right turn from Riccarton Road into Matipo Street having a dedicated phase. A summary of observed and modelled signal timings is provided in Appendix A10.

4.9 Intersection 9: Colombo Street/Peterborough Street

The four-arm stop-controlled intersection of Colombo Street/Peterborough Street is located in the Christchurch CBD. Colombo Street is a collector route carrying 10,000 vpd. Peterborough Street is an unclassified local road carrying an estimated 1,000 vpd. The intersection is shown in Figure 4-17. Photographs of each approach are presented in Appendix A11.

Figure 4-17 - Colombo Street/Peterborough Street Aerial

The intersection was manually surveyed on Monday 2 October 2006. The observed turning movements during the hour 2:45-3:45pm are shown in Figure 4-18 below. Full survey data is presented in Appendix A11.

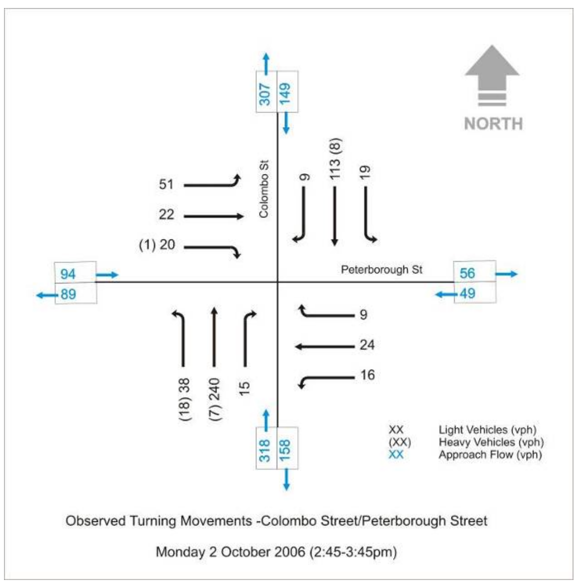


Figure 4-18 - Colombo Street/Peterborough Street Turning Movements

4.10 Intersection 10: Halswell Junction Road/Main South Road

The four-arm give way controlled intersection of Main South Road (SH1) and Halswell Junction Road is located on the western fringe of Christchurch. Main South Road forms part of the State Highway 1 route and carries some 18,600 vpd in this location. Halswell Junction Road is a major arterial carrying 5,500 vpd. The surrounding land use is rural industrial. The intersection is shown in Figure 4-19. Photographs of each approach are presented in Appendix A12.

Figure 4-19 - Halswell Junction Road/Main South Road Aerial Photograph

The intersection was manually surveyed on Wednesday 8 November 2006. The observed turning movements during the hour 4:45-5:45pm are shown in Figure 4-20 below. Full survey data is presented in Appendix A12.

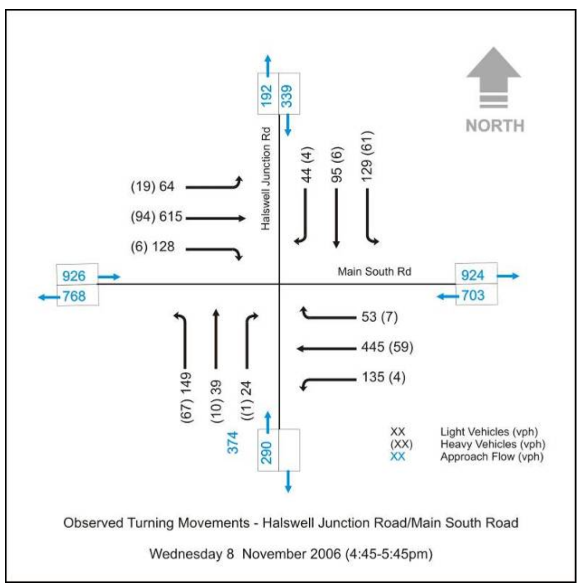


Figure 4-20 – Halswell Junction Road/Main South Road Turning Movements

5 Individual Intersection Analysis

Each of the ten selected intersections was subjected to a full range of tests using the Method 1 and Method 2 volumes as described in Section 3.3. A full description is presented in this section for Intersection 1, which is a three-arm priority intersection and Intersection 2, which is a four-arm signalised intersection.

Intersections 3 to 10 are described in more condensed style including summary results for Method 1 and a full discussion of all testing. The full range of results, as presented here for Intersection 1 and 2, for all the other intersections is presented in Appendices A5 to A12.

For all ten intersections, tabular results including percentiles and all data that is presented in the graphs are also presented in Appendices A3 to A12.

5.1 Intersection 1: Barbadoes Street Warrington Street

5.1.1 Journey Times Method 1

Figure 5-1 to Figure 5-3 present journey time comparisons for the right and left turn movements off the major road (Warrington Street) and for the average journey time for all movements through the intersection.

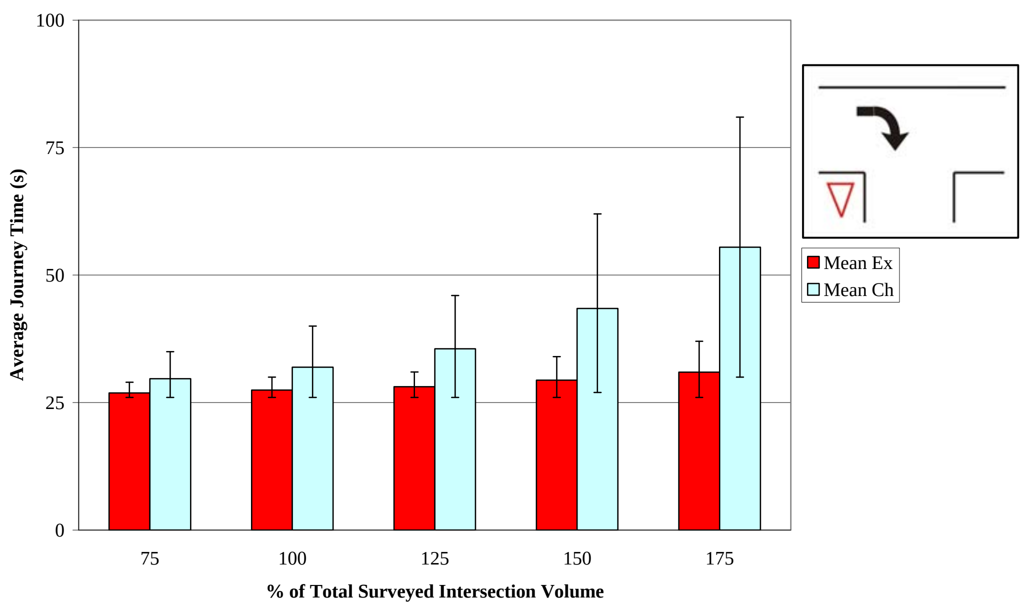


Figure 5-1 - Intersection 1, M1, Major Road Right Turn Journey Time Comparison

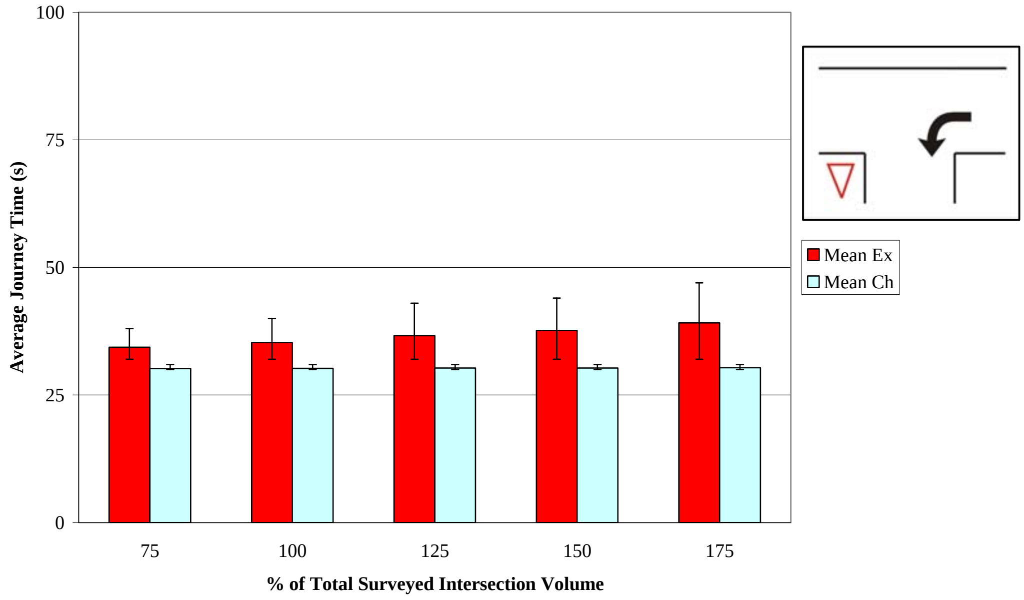


Figure 5-2 - Intersection 1, M1, Major Road Left Turn Journey Time Comparison

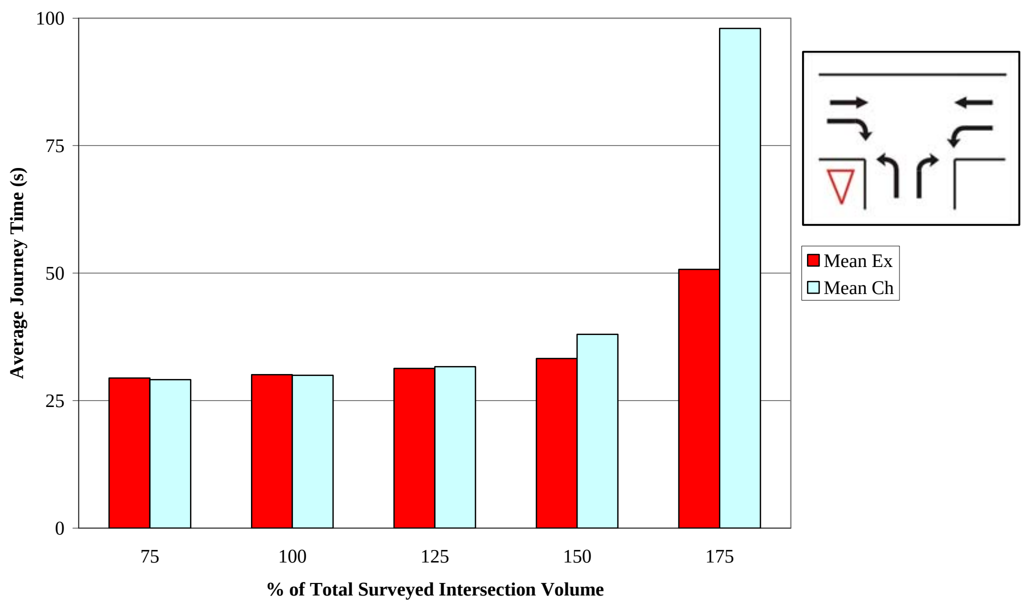


Figure 5-3 - Intersection 1, M1, Average Journey Time Comparison (All Movements)

Table 5-1 summarises the average journey times for all movements for each volume scenario.

Table 5-1 - Intersection 1, M1, Average Journey Time Comparison

Approach	Mvt	Average Journey Time (s/veh) for Various % Scenarios									
		75%		100%		125%		150%		175%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Warrington Street (West)	T	20	20	20	20	20	20	20	20	20	20
	R	27	30	27	32	28	36	29	43	31	55
Barbadoes Street (South)	L	49	49	50	50	51	51	53	66	139	547
	R	54	56	59	62	68	75	84	127	227	686
Warrington Street (East)	T	27	27	27	27	27	27	27	27	27	27
	L	34	30	35	30	37	30	38	30	39	30
Total	**All**	**29**	**29**	**30**	**30**	**31**	**32**	**33**	**38**	**51**	**98**

It is evident from the analysis that with the changed rule, as expected, that the right turn journey increases and the left turn journey time decreases. The graphs also show a greater spread of journey times for right turners as the total intersection volume increases, particularly under the changed rule.

The journey times for movements out of the minor road, Barbadoes Street increase significantly under the changed rule, particularly as the total volume through the intersection increases. This is due to the greater journey times experienced by right turning vehicles off the major road, Warrington Street. With right turning vehicles queued in the right turn bay on Warrington Street, right turning vehicles out of Barbadoes Street are unable to make their turn and journey times and queues increase. The Barbadoes Street approach has a short two-lane section where right turning and left turning vehicles can queue side by side. Once the queue of right turning vehicles exceeds the available storage capacity, left turning vehicles out of Barbadoes Street also become affected and their journey times increase also.

Table 5-2 presents a summary of the increase or decrease in journey time for these two movements as a result of the rule change to near side priority.

Table 5-2 – Intersection 1, M1, Right and Left Turn Average Journey Time Changes

Movement	Change in Average Journey Time (s/veh) for Various % Scenarios				
	75%	100%	125%	150%	175%
Major Road Right Turn	3	4	7	14	25
Major Road Left Turn	-4	-5	-6	-7	-9

Table 5-2 highlights that the increase in right turn journey time as a result of the rule change to near side priority is approximately matched by the decrease in left turn journey time for the first three volume scenarios. For the last two scenarios the increase in right turn journey time is two to three times greater than the corresponding decrease for the left turn.

This is also reflected in the overall intersection performance. Figure 5-3 clearly illustrates that the average journey time through the intersection is greater following the rule change to near side priority and this is increasingly true as the total volume through the intersection increases.

5.1.2 Journey Times Method 2

Figure 5-4 to Figure 5-6 present journey time comparisons for the right and left turn movements off the major road (Warrington Street) and for the overall journey time for all movements through the intersection.

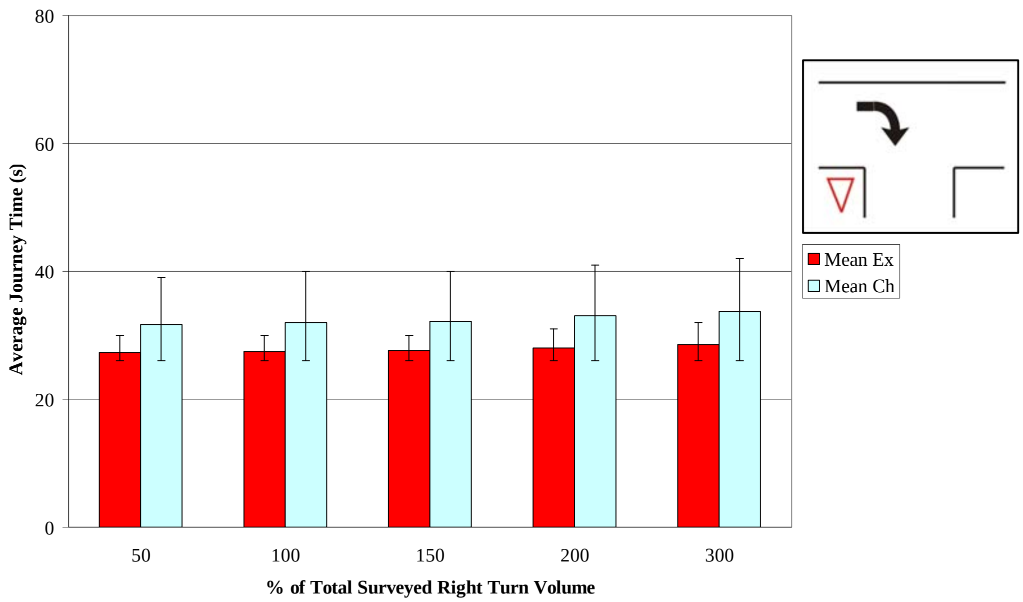


Figure 5-4 - Intersection 1, M2, Major Road Right Turn Journey Time Comparison

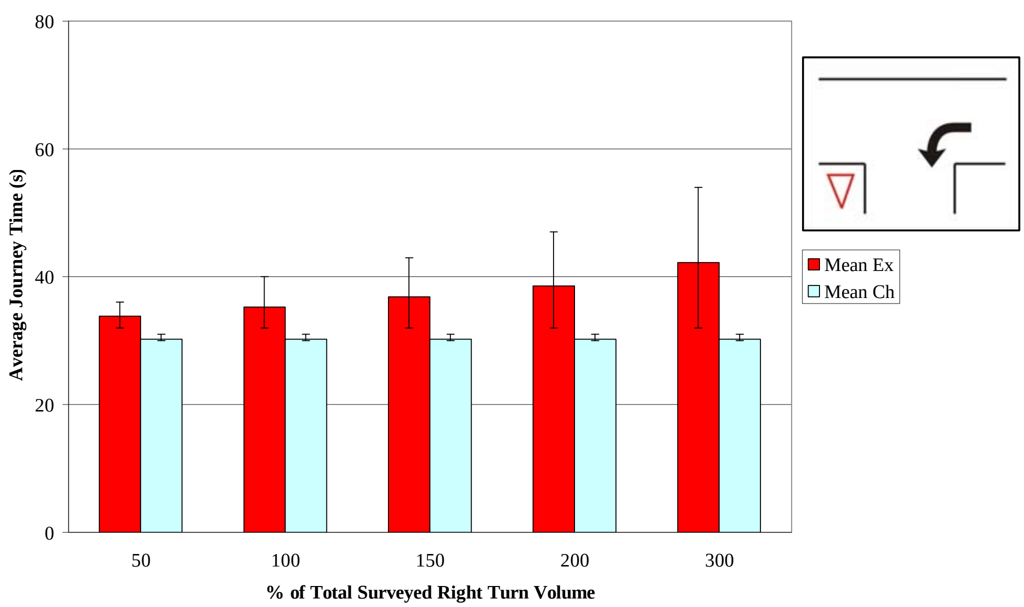


Figure 5-5 - Intersection 1, M2, Major Road Left Turn Journey Time Comparison

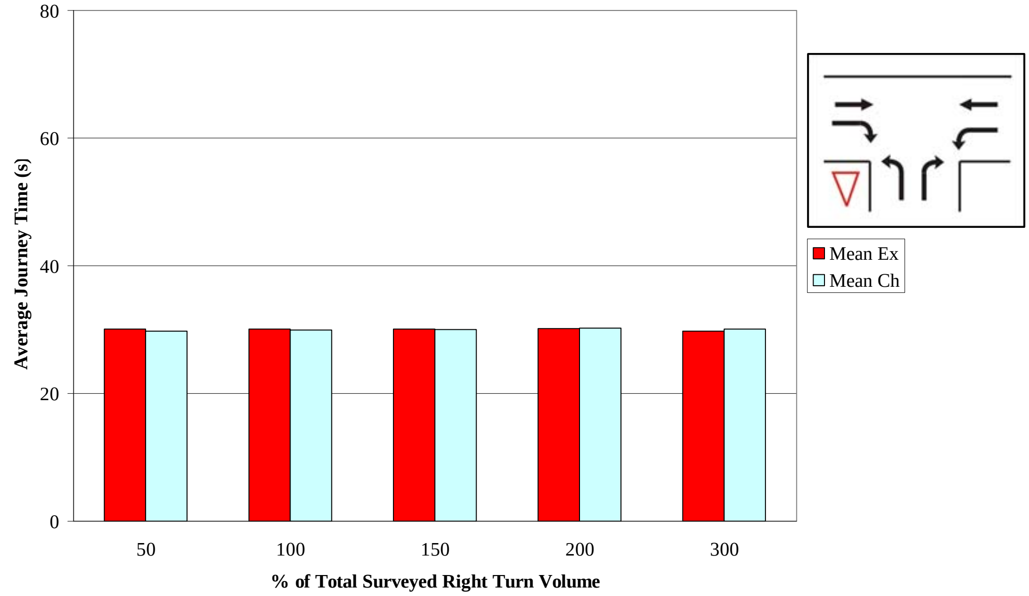


Figure 5-6 - Intersection 1, M2, Average Journey Time Comparison (All Movements)

Table 5-3 summarises the average journey times for all movements for each volume scenario.

Table 5-3 - Intersection 1, M2, Average Journey Time Comparison

Approach	Mvt	Average Journey Time (s/veh) for Various % Scenarios									
		50%		100%		150%		200%		300%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Warrington Street (West)	T	20	20	20	20	20	20	20	20	20	20
	R	27	32	27	32	28	32	28	33	29	34
Barbadoes Street (South)	L	50	50	50	50	50	50	50	50	48	48
	R	56	57	59	62	62	65	65	70	69	73
Warrington Street (East)	T	27	27	27	27	27	27	27	27	27	27
	L	34	30	35	30	37	30	39	30	42	30
Total	All	30	30	30	30	30	30	30	30	30	30

It is evident from the analysis that with the changed rule, as expected, that the right turn journey increases and the left turn journey time decreases. Table 5-4 presents a summary of the increase or decrease for these two movements as a result of the rule change to near side priority.

Table 5-4 – Intersection 1, M1, Right and Left Turn Journey Time Changes

Movement	Change in Journey Time (s/veh) for Various % Scenarios				
	75%	100%	125%	150%	175%
Major Road Right Turn	4	4	5	5	5
Major Road Left Turn	-4	-5	-7	-8	-12

Table 5-4 highlights that the increase in right turn journey time as a result of the rule change to near side priority is approximately matched by the decrease in left turn journey time for the first three volume scenarios. For the last two scenarios the decrease in left turn journey time is around two times greater than the corresponding increase for the right turn.

This can be interpreted as showing that as the number of right turning vehicles increases, the decrease in journey time afforded to left turners by a rule change to near side priority becomes more significant.

Overall there is no difference in the average journey time for all movements through the intersection. This indicates that at the surveyed total intersection volume, the proportion of right turning vehicles has little impact on the overall performance of the intersection under either rule.

5.1.3 Queue Lengths Method 1

Figure 5-7 and Figure 5-8 present queue length comparisons for right and left turns off the major road, Warrington Street. It is noted that where a maximum queue length bar does not appear on the graph this is due to the maximum and average queue length being equal which can occur at low values.

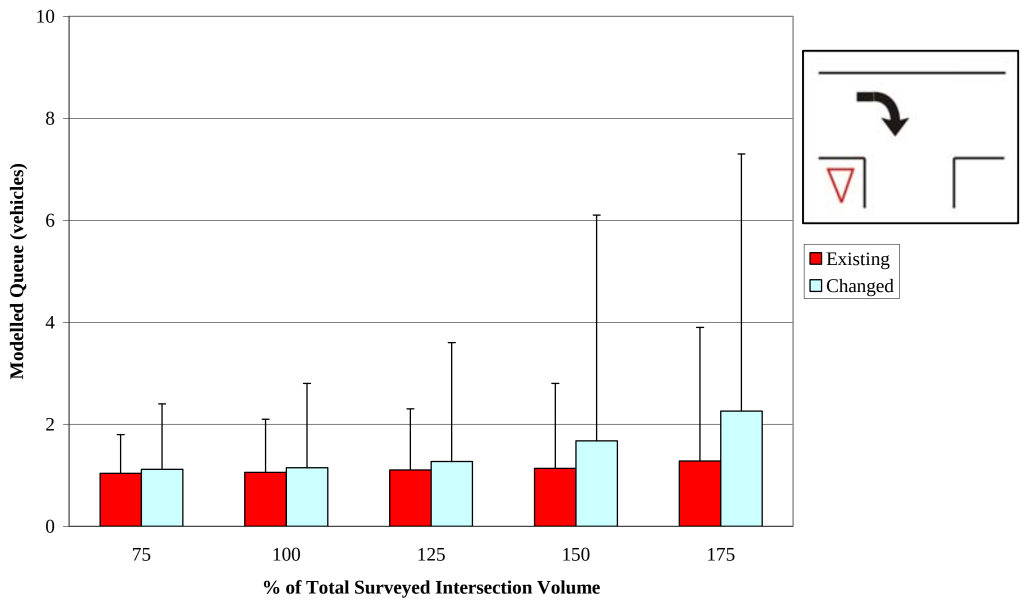


Figure 5-7 - Intersection 1, M1, Major Road Right Turn Queue Comparison

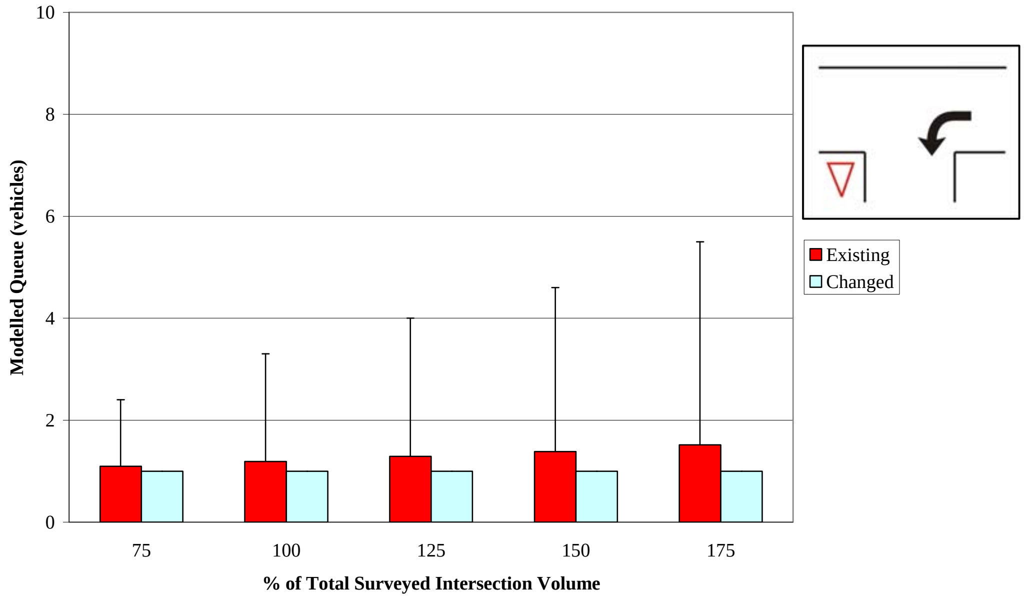


Figure 5-8- Intersection 1, M1, Major Road Left Turn Queue Comparison

Figure 5-9 presents the queue comparison for the minor road (Barbadoes Street). Barbadoes Street has a short two-lane section on the approach to the intersection, one lane for left turning vehicles and one lane for right turning vehicles. The comparison has been made based on the length of the longest queue in any lane.

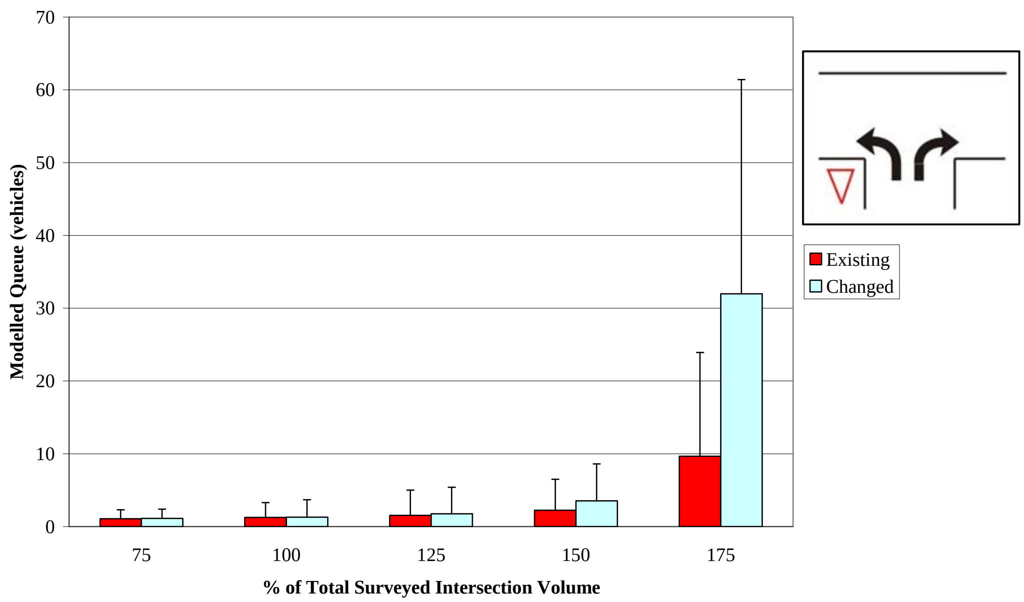


Figure 5-9 - Intersection 1, M1, Minor Road Queue Comparison (Longest Queue in Any Lane)

Table 5-5 summarises the average queue lengths for all movements for each volume scenario.

Table 5-5 - Intersection 1, M1, Average Queue Comparison

Approach	Mvt	Average Queue Length (vehicles) for Various % Scenarios									
		75%		100%		125%		150%		175%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Warrington Street (East)	L	1.1	1.0	1.2	1.0	1.3	1.0	1.4	1.0	1.5	1.0
	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Barbadoes Street (South)	L	1.0	1.0	1.0	1.0	1.2	1.1	1.3	3.0	9.7	32.0
	R	1.1	1.1	1.3	1.3	1.5	1.8	2.2	3.5	4.9	6.1
Warrington Street (West)	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	R	1.0	1.1	1.1	1.1	1.1	1.3	1.1	1.7	1.3	2.3

It is evident from the analysis that with the changed rule the right turn queue length increases and the left turn queue length decreases. The increase and decrease are similar in scale with the increase in right turn queue length being slightly greater.

The effect on the minor road is more dramatic. Under the changed rule the average queue increases by 20 vehicles. This is a result of the greater journey time experienced by the right turning vehicles off the major road under the changed rule and the reduced opportunity this gives right turning vehicles from the minor road to find gaps.

5.1.4 Queue Lengths Method 2

Figure 5-10 and Figure 5-11 present queue length comparisons for right and left turns off the major road, Warrington Street.

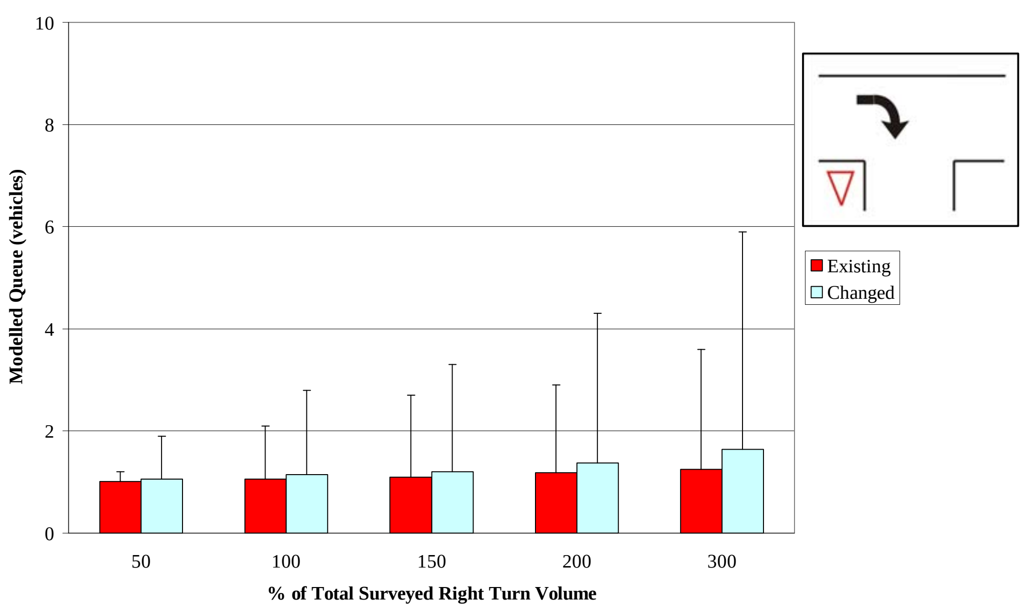


Figure 5-10 - Intersection 1, M2, Major Road Right Turn Queue Comparison

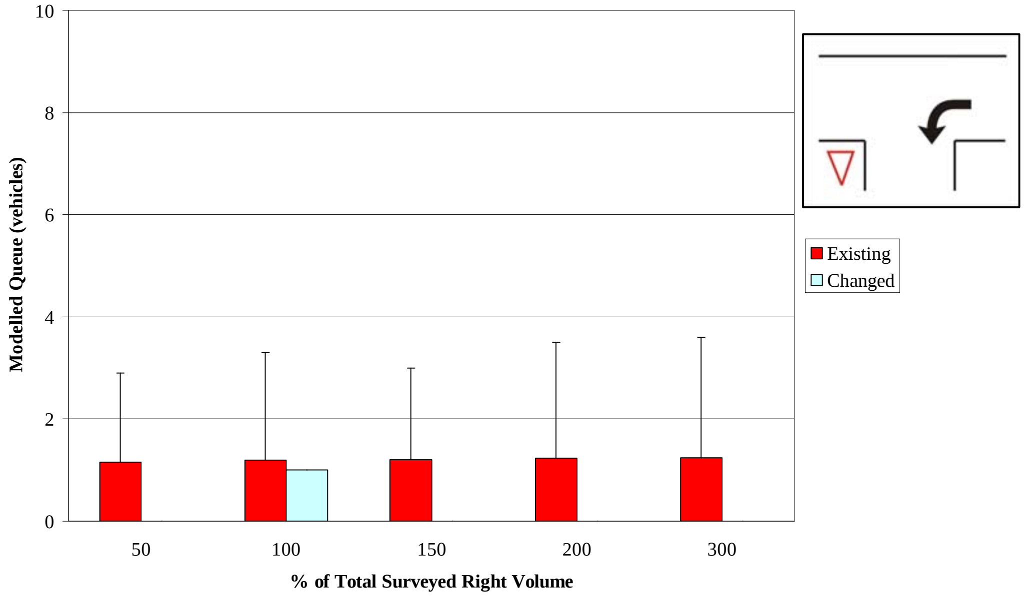


Figure 5-11 - Intersection 1, M2, Major Road Left Turn Queue Comparison

Figure 5-12 presents the queue comparison for the minor road, Barbadoes Street. Barbadoes Street has a short two-lane section on the approach to the intersection, one lane for left turning vehicles and one lane for right turning vehicles. The comparison has been made based on the length of the longest queue in any lane at any time.

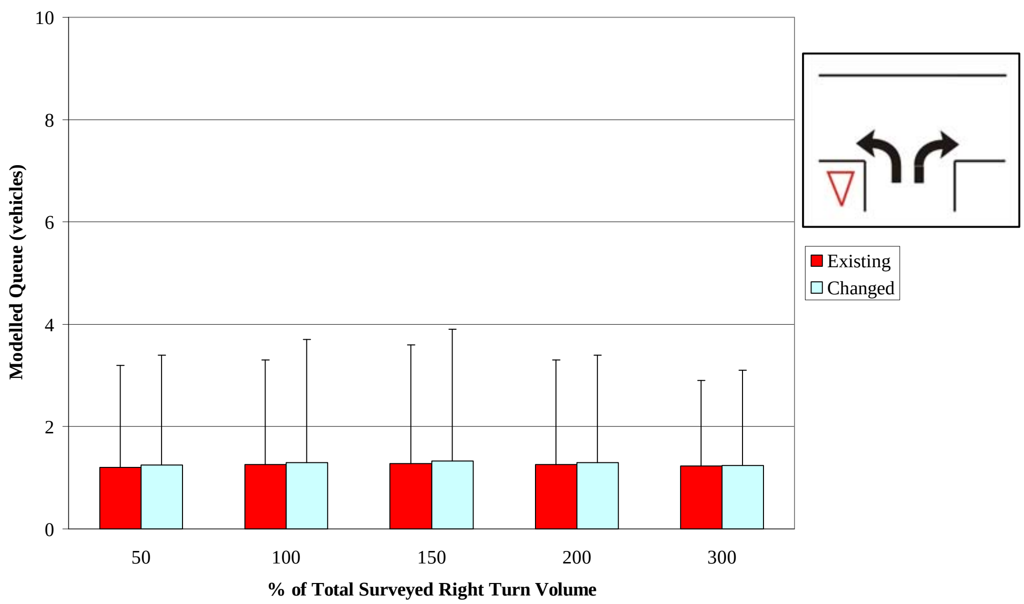


Figure 5-12 - Intersection 1, M2, Minor Road Queue Comparison

Table 5-6 summarises the average queue lengths for all movements for each volume scenario.

Table 5-6 - Intersection 1, M2, Average Queue Comparison

Approach	Mvt	Average Queue Length (vehicles) for Various % Scenarios									
		50%		100%		150%		200%		300%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Warrington Street (East)	L	1.2	0.0	1.2	1.0	1.2	0.0	1.2	0.0	1.2	0.0
	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Barbadoes Street (South)	L	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	R	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.2
Warrington Street (West)	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	R	1.0	1.1	1.1	1.1	1.1	1.2	1.2	1.4	1.2	1.6

It is evident from the analysis that with the changed rule the right turn queue length increases very slightly as the proportion of right turning vehicles increases.

Overall there is very little difference in the queue lengths at the intersection. This indicates that at the surveyed total intersection volume, the proportion of right turning vehicles has little impact on the overall performance of the intersection under either rule.

5.1.5 Discussion

The analysis has shown that the intersection of Barbadoes Street/Warrington Street which is a three-arm, give-way controlled intersection with separate left and right turn lanes operates more efficiently under the existing rule than it would under the changed rule.

This is highlighted particularly clearly as the total volume through the intersection is increased as in Method 1. The results of the analysis show that it becomes increasingly difficult to turn right off the major road (Warrington Street) as the total intersection volume increases. This is worsened by the changed rule. Not only does the changed rule impact on the journey time and queue lengths of right turning vehicles but the minor road (Barbadoes Street) also suffers as a consequence. There is some benefit to left turning vehicles off the major road however this is small compared to the increases to right turning vehicles.

The analysis suggests that possible implications of a rule change to near side priority at this intersection could include the need for a longer right turn lane on Warrington Street and the need for signalisation may be brought forward based on the journey times for this movements and also the movements from the minor road.

5.2 Intersection 2: Breezes Road/Pages Road

5.2.1 Journey Times Method 1

Figure 5-13 to Figure 5-16 present the average journey times for the four right turn movements at the intersection.

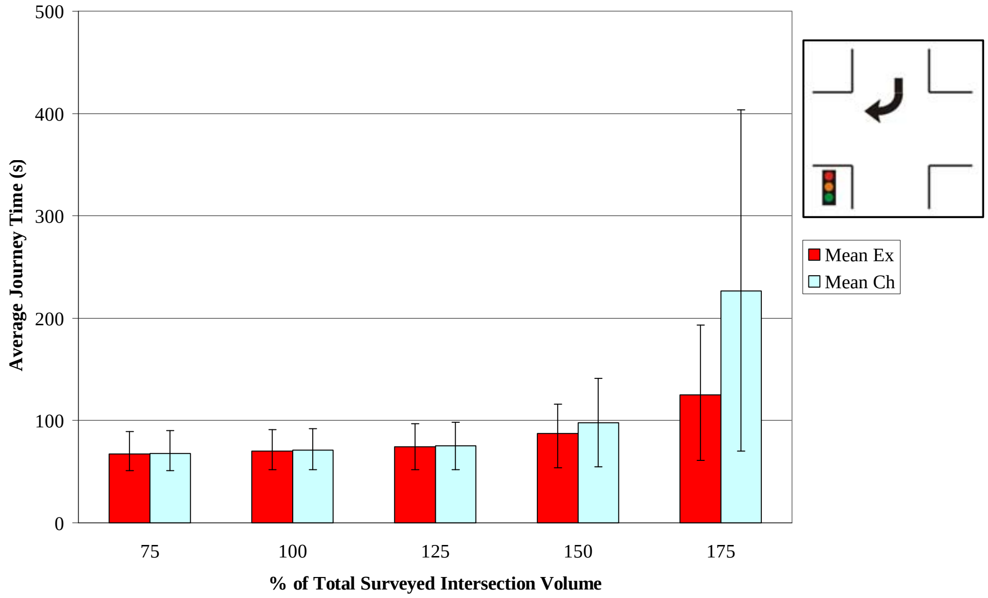


Figure 5-13 - Intersection 2, M1, Breezes Road (North) Right Turn Journey Time Comparison

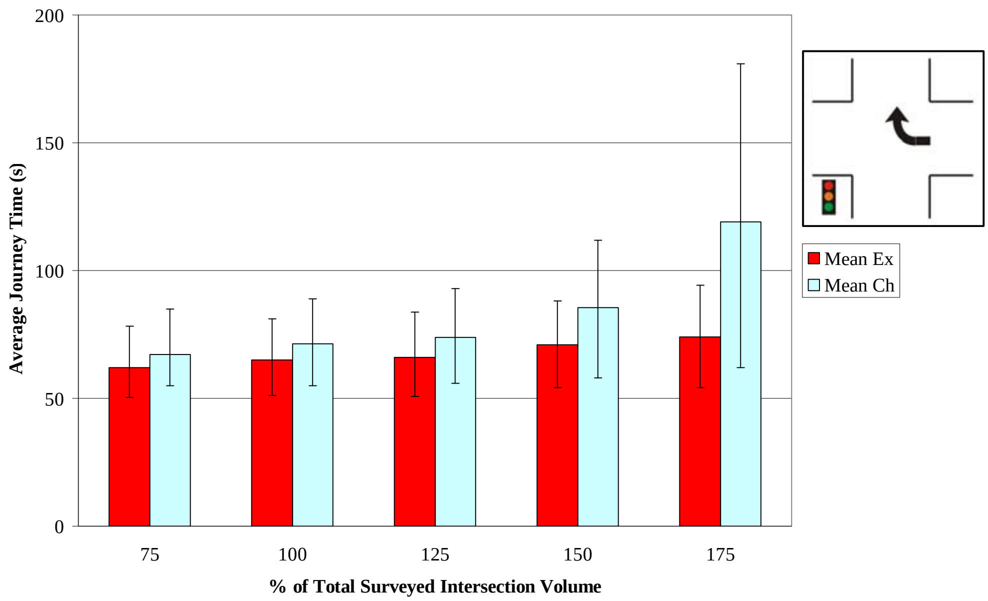


Figure 5-14 – Intersection 2, M1, Pages Road (East) Right Turn Journey Time Comparison

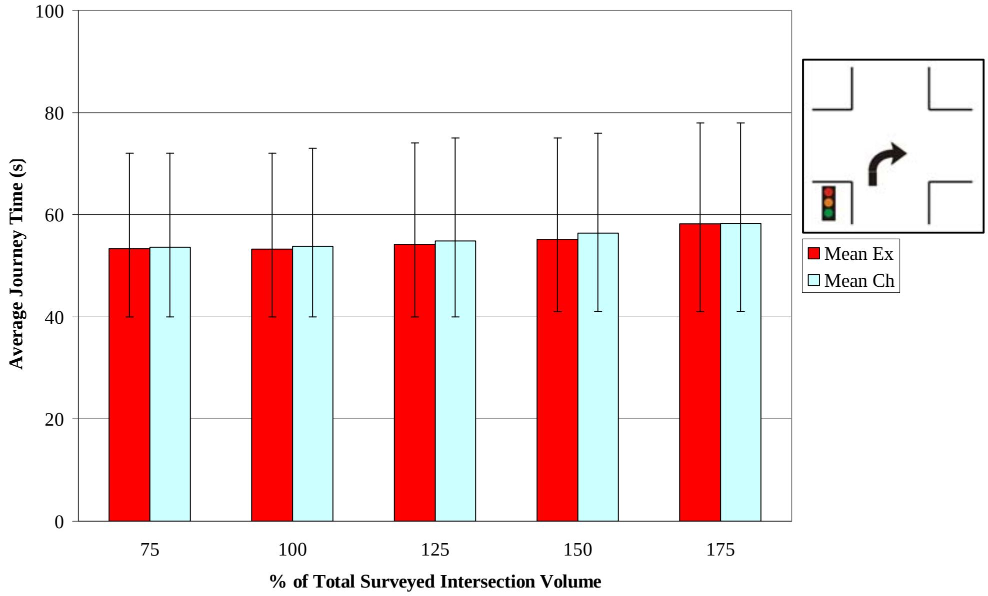


Figure 5-15 - Intersection 2, M1, Breezes Road (South) Right Turn Journey Time Comparison

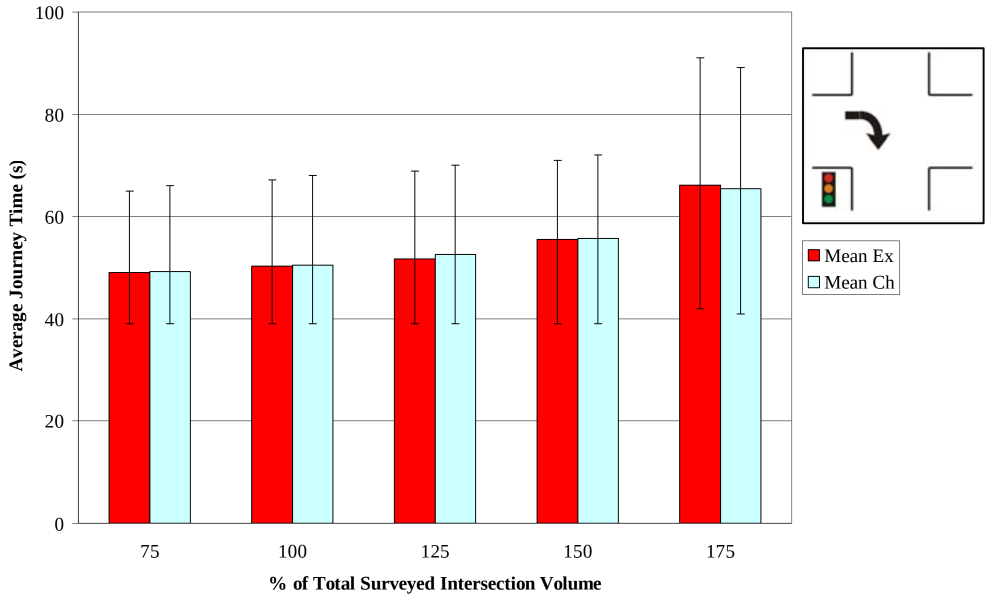


Figure 5-16 - Intersection 2, M1, Pages Road (West) Right Turn Journey Time Comparison

The graphs show all right turn journey times increase, albeit only slightly, following the rule change to near side priority and the size of the increase increases as the total volume through the intersection increases. On the north and east approaches the increased difficulty faced by right turn vehicles causes blocking of other movements on the approach. This is illustrated in Figure 5-17.

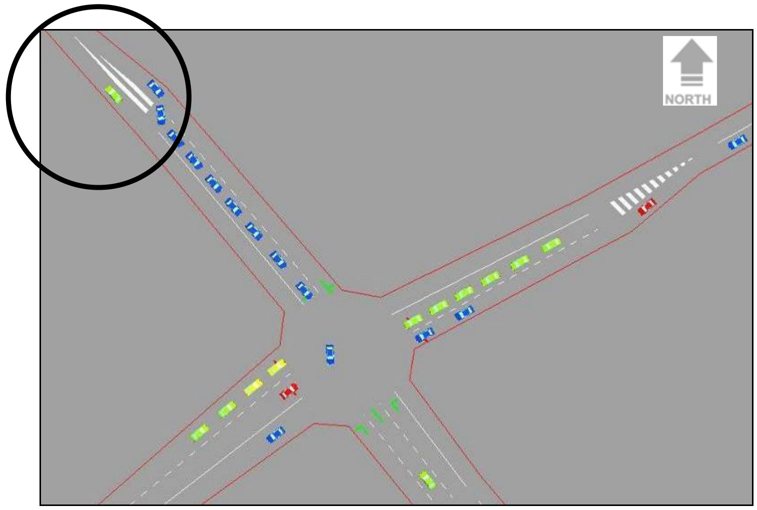


Figure 5-17 – Right Turn Lane Blocking Through Movement

Figure 5-18 to Figure 5-21 present the average journey times for the four left turn movements through the intersection.

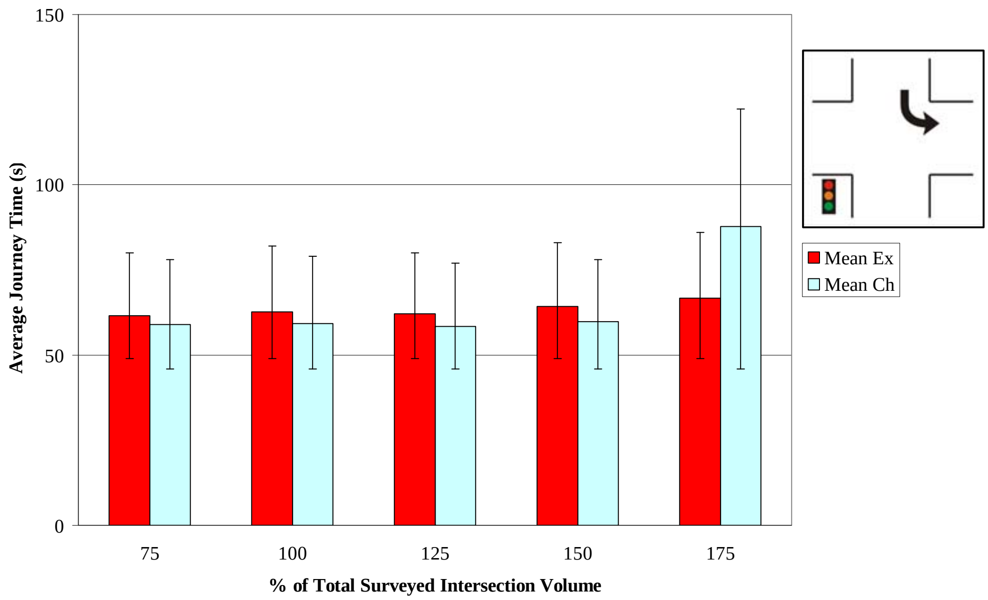


Figure 5-18 - Intersection 2, M1, Breezes Road (North) Left Turn Journey Time Comparison

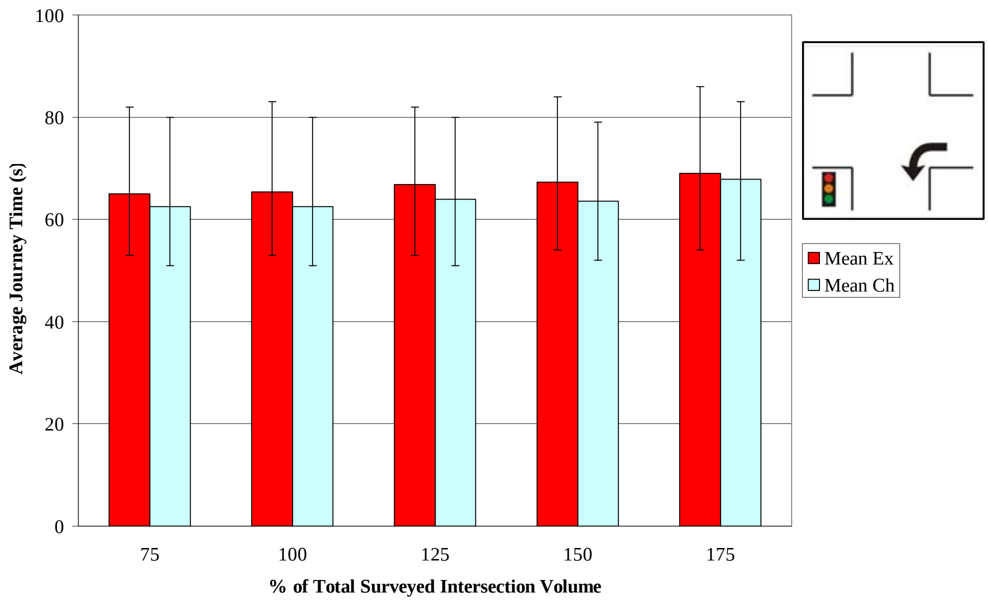


Figure 5-19 – Intersection 2, M1, Pages Road (East) Left Turn Journey Time Comparison

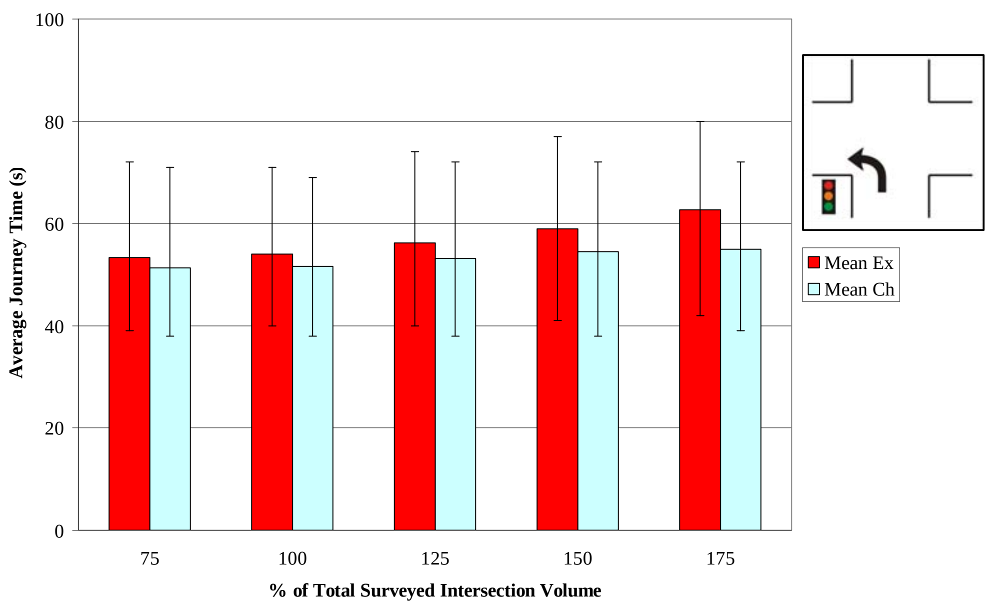


Figure 5-20 - Intersection 2, M1, Breezes Road (South) Left Turn Journey Time Comparison

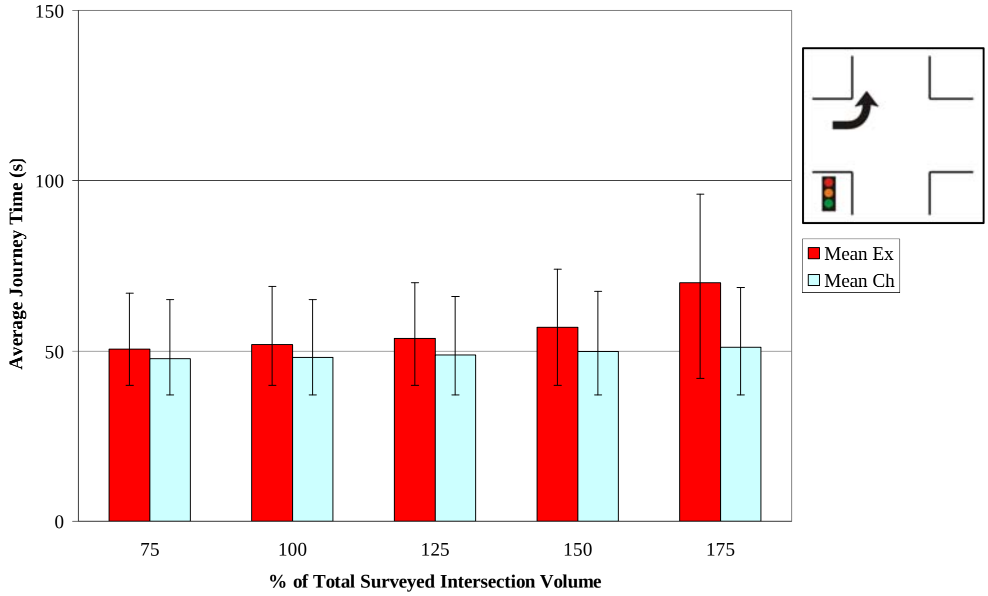


Figure 5-21 - Intersection 2, M1, Pages Road (West) Left Turn Journey Time Comparison

Figure 5-18 to Figure 5-21 show that there is a relatively consistent decrease in left turn journey time following the rule change to near side priority for all approaches and all volume scenarios. The size of the decrease grows as the total volume through the intersection increases. At the 175% scenario on the northern approach the left turn journey actually increases following the rule change to near side priority. This is due to the fact that the right turning vehicles on this approach are queuing back and blocking the approach, preventing through and left turning vehicles getting through. This was illustrated above in Figure 5-17. Figure 5-22 shows the average journey time for all movements through the intersection under each rule.

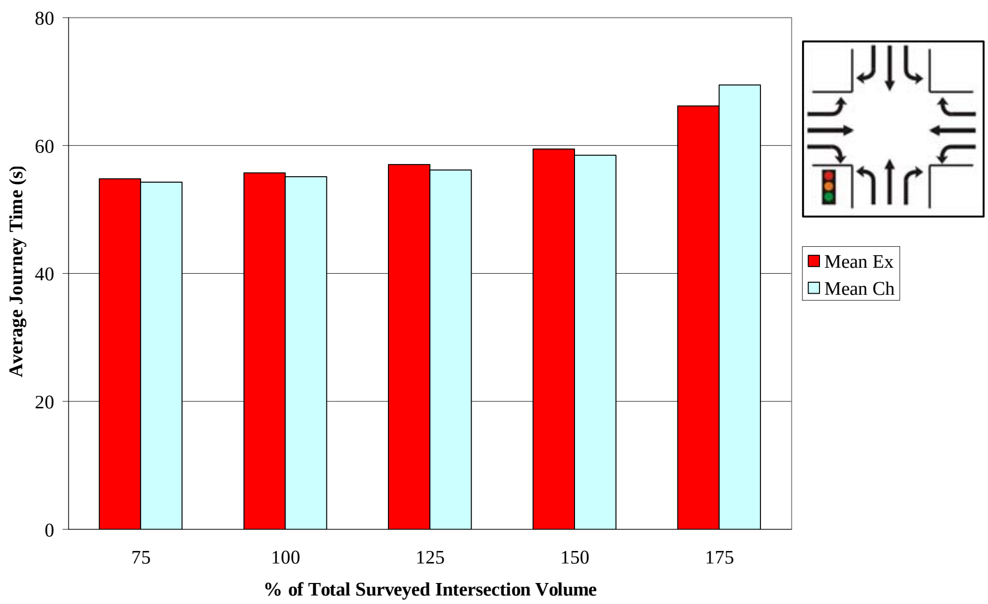


Figure 5-22 - Intersection 2, M1, Average Journey Time Comparison (All Movements)

Overall the average journey time through the intersection is slightly better under the changed rule for the first four scenarios but the existing rule proves more efficient at the 175% scenario.

Table 5-7 summarises the average journey time for all movements for each volume scenario.

Table 5-7 - Intersection 2, M1, Average Journey Time Comparison

Approach	Mvt	Average Journey Time (s/veh) for Various % Scenarios									
		75%		100%		125%		150%		175%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Breezes Road (North)	L	62	59	63	59	62	58	64	60	67	88
	T	57	57	57	57	58	57	59	58	60	84
	R	67	68	70	71	74	75	87	98	125	227
Pages Road (East)	L	65	63	65	62	67	64	67	64	69	68
	T	63	62	63	63	65	64	65	64	67	69
	R	67	67	69	71	70	74	74	86	78	119
Breezes Road (South)	L	53	51	54	52	56	53	59	55	63	55
	T	49	49	50	50	51	50	52	51	56	52
	R	53	54	53	54	54	55	55	56	58	58
Pages Road (West)	L	51	48	52	48	54	49	57	50	70	51
	T	47	47	48	47	49	48	52	48	64	49
	R	49	49	50	50	52	53	55	56	66	65
Total	All	55	54	56	55	57	56	59	58	66	69

Table 5-8 presents a comparison for the increase or decrease in journey time for each right turn and the opposing left turn.

Table 5-8 - Intersection 2, M1, Right and Left Turn Journey Time Changes

Movement	Change in Average Journey Time (s/veh) for Various % Scenarios				
	75%	100%	125%	150%	175%
Breezes Road (North) R	0.7	1.1	0.9	10.6	101.9
Breezes Road (South) L	-2.0	-2.4	-3.0	-4.5	-7.7
Pages Road (East) R	0.5	2.5	3.7	11.7	41.4
Pages Road (West) L	-2.9	-3.7	-4.8	-7.3	-18.8
Breezes Road (South) R	0.3	0.6	0.7	1.2	0.1
Breezes Road (North) L	-2.6	-3.5	-3.8	-4.4	21.0
Pages Road (West) R	0.2	0.2	0.9	0.3	-0.7
Pages Road (East) L	-2.4	-2.8	-2.9	-3.7	-1.1

Table 5-8 shows that for the first four scenarios there is a small increase in journey time for each right turn and a slightly larger increase for each left turn. For the 175% scenario the right turns from the north and east become critical and the increase in journey time is much greater than the corresponding reduction for the left turn. At this volume level the intersection operation breaks down.

The north and east approaches become particularly congested and blocking occurs. This causes the left turn journey time from Breezes Road (North) to actually increase under the changed rule despite it becoming an unopposed movement. This is due to the right turn queue extending sufficiently far back to block access to the shared left and through lane.

5.2.2 Journey Times Method 2

Figure 5-23 to Figure 5-26 present the average journey times for the four right turn movements at the intersection.

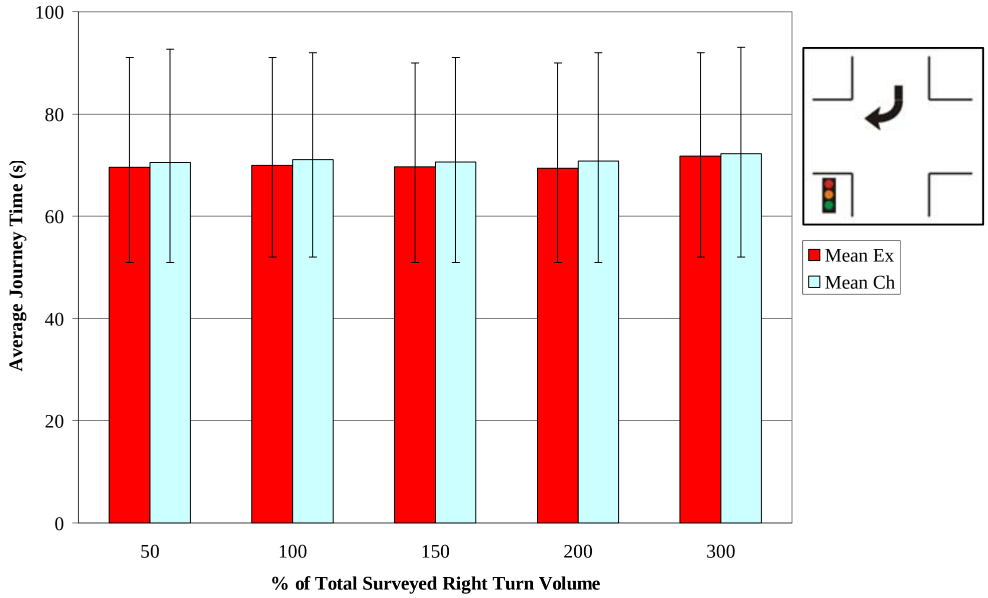


Figure 5-23 - Intersection 2, M2, Breezes Road (North) Right Turn Journey Time Comparison

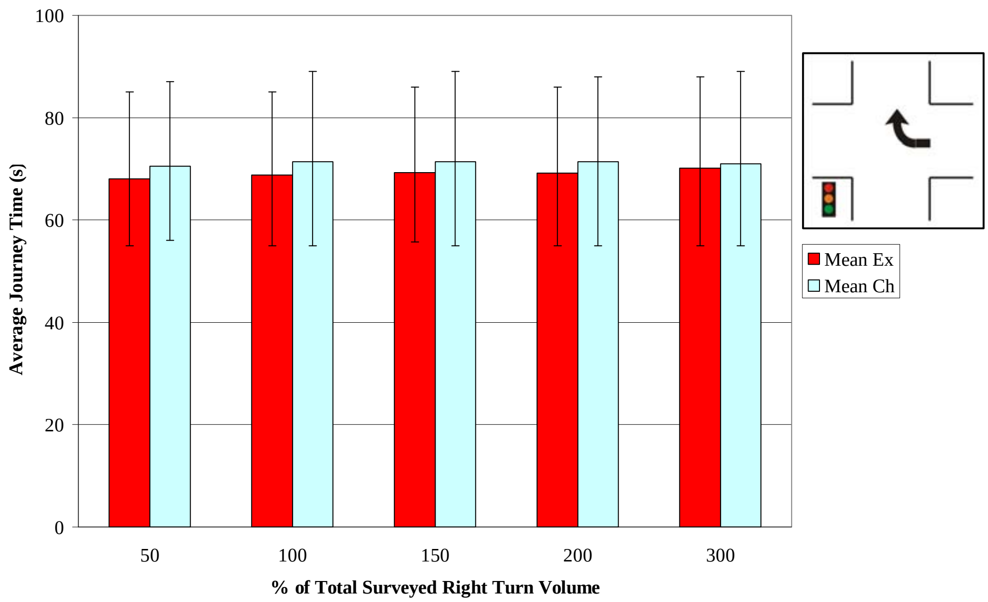


Figure 5-24 - Intersection 2, M2, Pages Road (East) Right Turn Journey Time Comparison

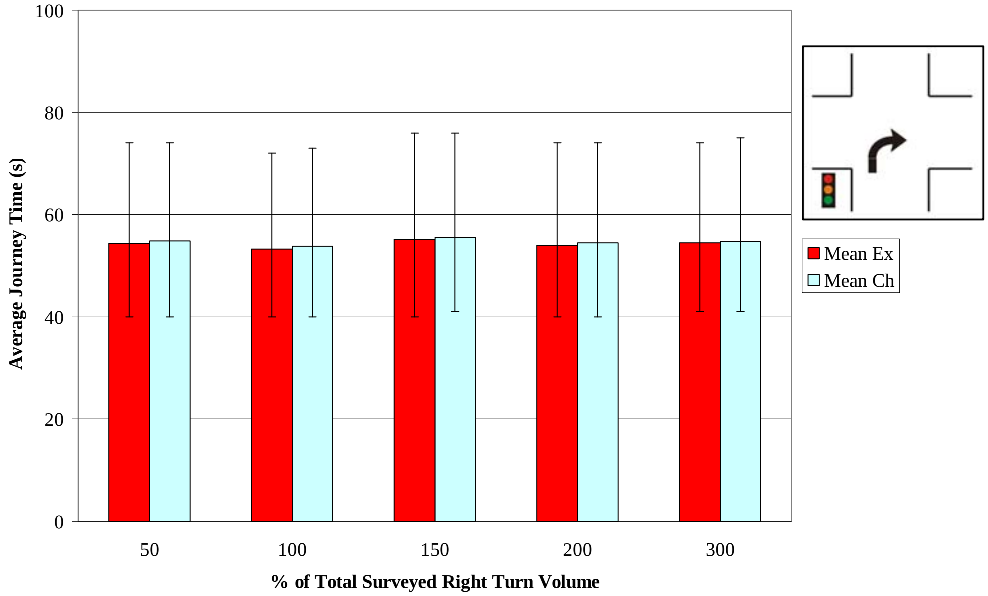


Figure 5-25 – Intersection 2, M2, Breezes Road (South) Right Turn Journey Time Comparison

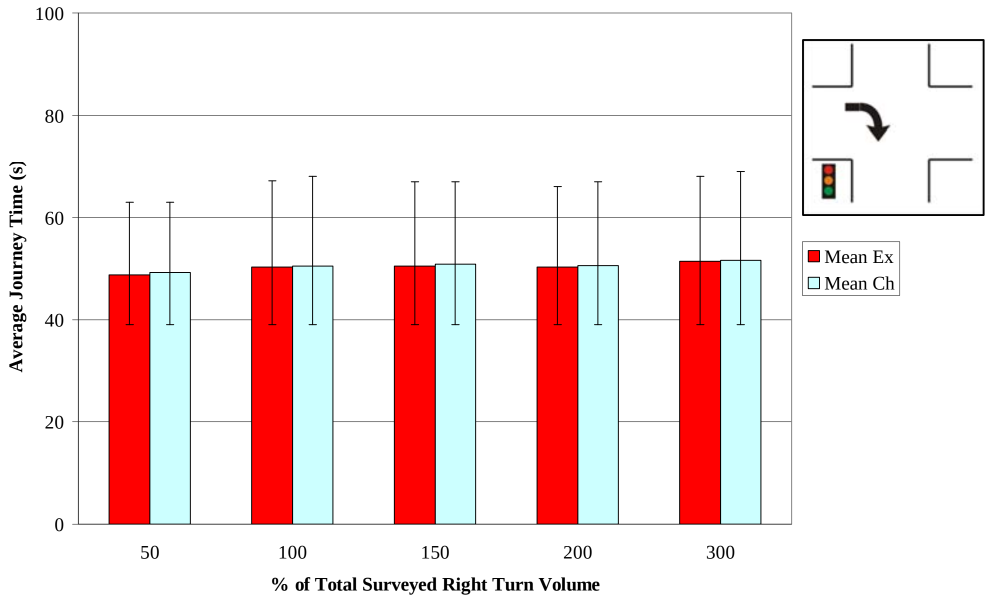


Figure 5-26 - Intersection 2, M2, Pages Road (West) Right Turn Journey Time Comparison

Figure 5-27 to Figure 5-30 present the average journey times for the four left turn movements at the intersection.

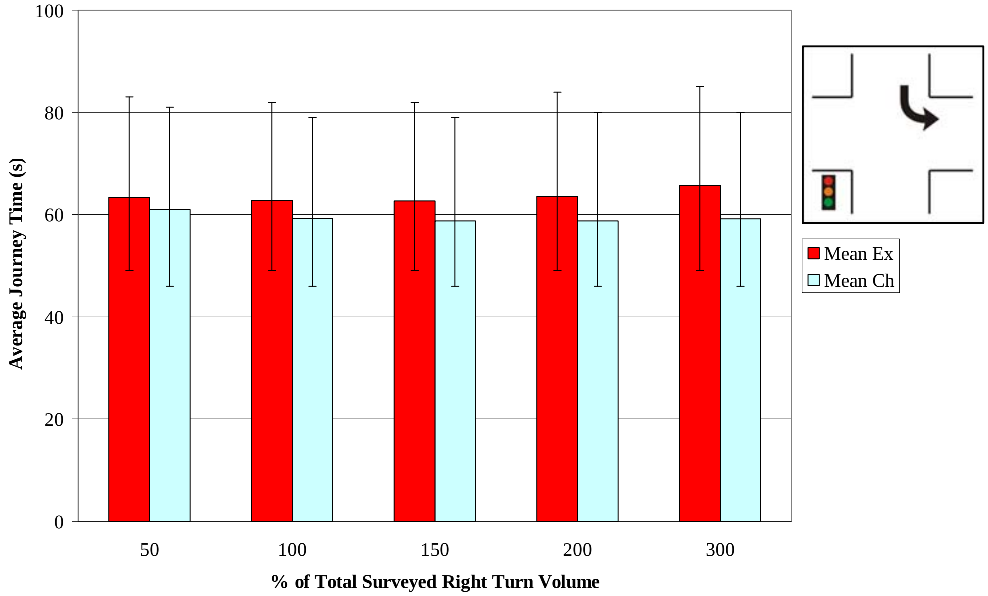


Figure 5-27 - Intersection 2, M2, Breezes Road (North) Left Turn Journey Time Comparison

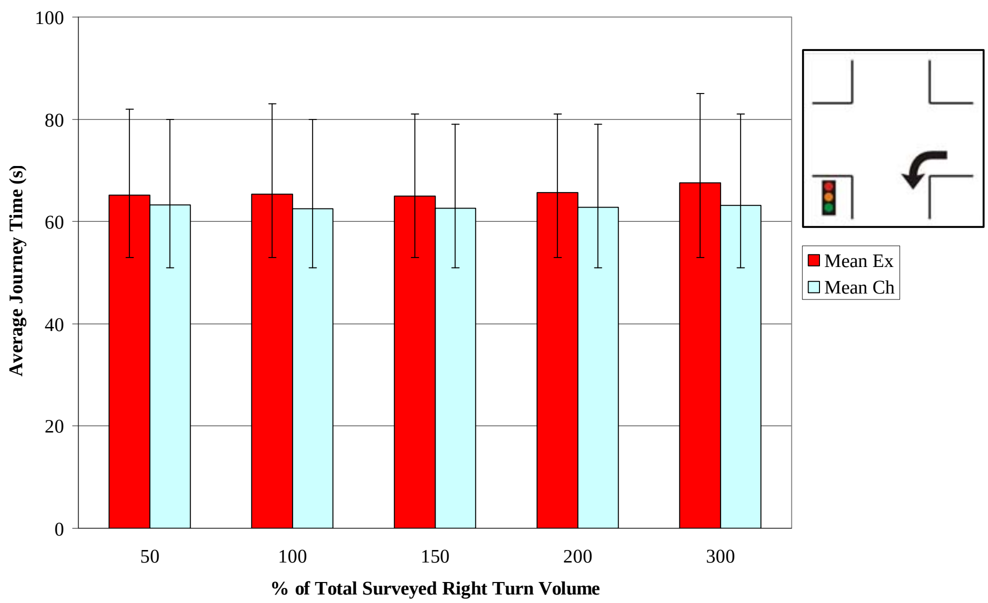


Figure 5-28 - Intersection 2, M2, Pages Road (East) Left Turn Journey Time Comparison

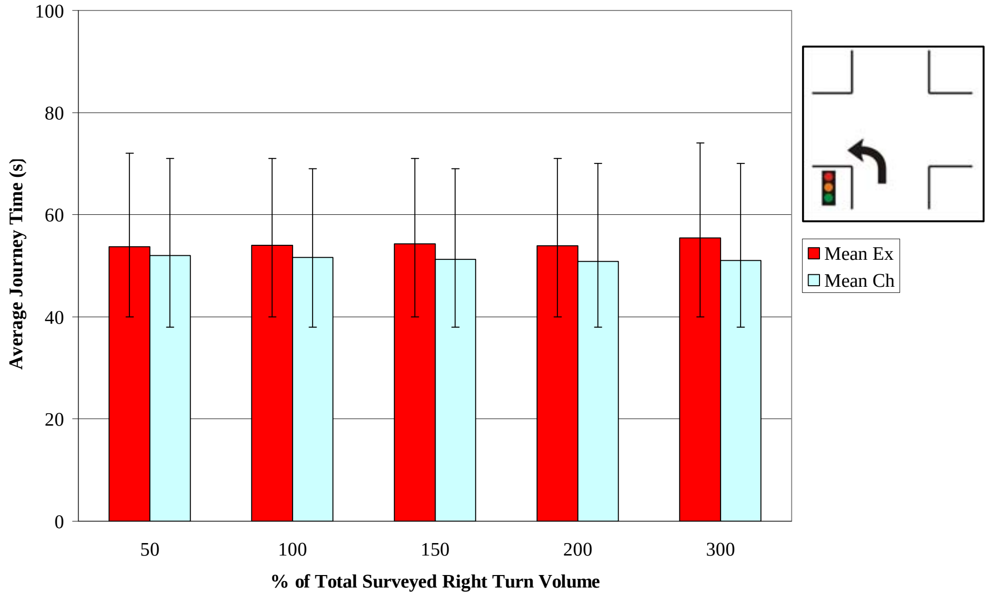


Figure 5-29 - Intersection 2, M2, Breezes Road (South) Left Turn Journey Time Comparison

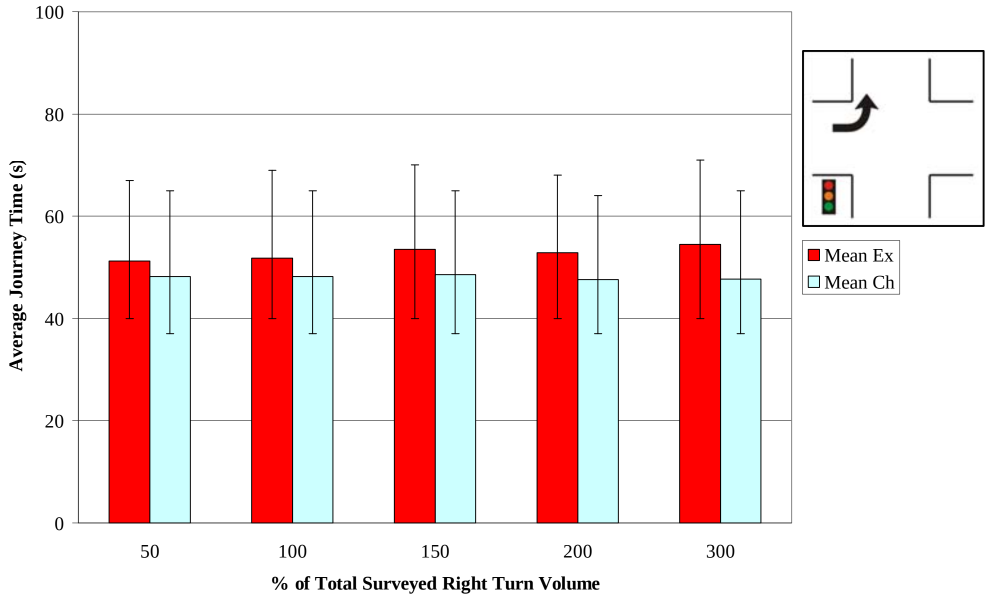


Figure 5-30 - Intersection 2, M2, Pages Road (West) Left Turn Journey Time Comparison

Figure 5-31 presents the average journey time for all movements through the intersection under each rule.

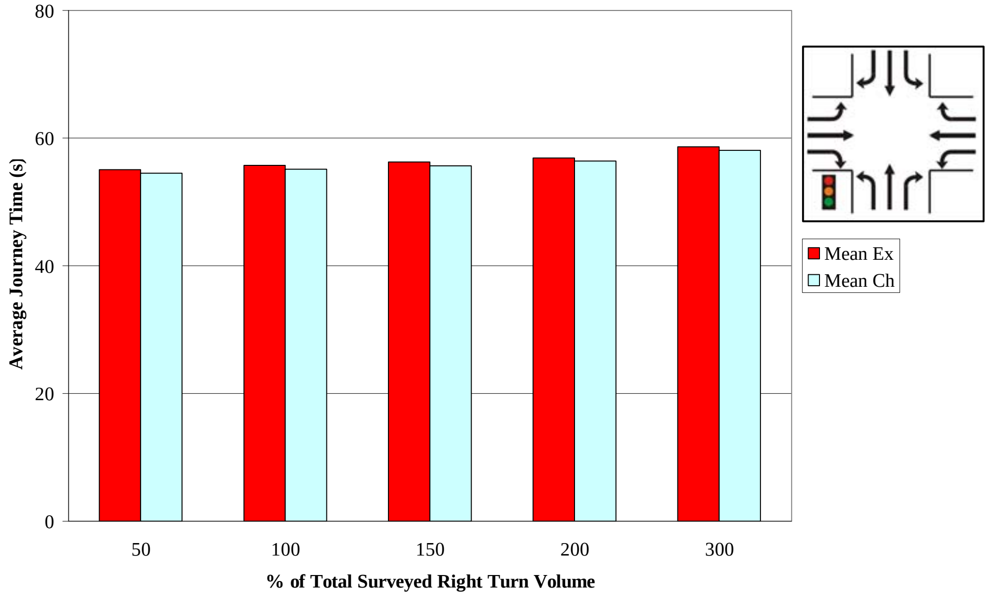


Figure 5-31 - Intersection 2, M2, Total Intersection Journey Time Comparison

Table 5-9 summarises the average journey time for all movements for each volume scenario.

Table 5-9 - Intersection 2, M2, Average Journey Time Comparison

Approach	Mvt	Average Journey Time (s/veh) for Various % Scenarios									
		50%		100%		150%		200%		300%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Breezes Road (North)	L	63	61	63	59	63	59	64	59	66	59
	T	57	57	57	57	56	56	58	57	57	57
	R	70	70	70	71	70	71	69	71	72	72
Pages Road (East)	L	65	63	65	62	65	63	66	63	68	63
	T	64	64	63	63	63	63	63	63	63	63
	R	68	71	69	71	69	71	69	71	70	71
Breezes Road (South)	L	54	52	54	52	54	51	54	51	55	51
	T	50	50	50	50	49	49	50	49	48	48
	R	54	55	53	54	55	56	54	54	54	55
Pages Road (West)	L	51	48	52	48	54	49	53	48	55	48
	T	48	47	48	47	48	47	48	46	47	46
	R	49	49	50	50	50	51	50	51	51	52
Total	All	55	55	56	55	56	56	57	56	59	58

It is evident from Figure 5-23 to Figure 5-30 and Table 5-9 that there is a consistent pattern through all scenarios of a small decrease in the left turn journey time and a corresponding, yet slightly smaller increase in right turn journey time.

Overall there is very little difference in intersection performance between the two rules. The changed rule gives slightly lower average journey times for all movements through the intersection however this difference is very small.

Table 5-10 presents a comparison for the increase or decrease in journey time for each right turn and the opposing left turn.

Table 5-10 - Intersection 2, M1, Right and Left Turn Journey Time Changes

Movement	Change in Average Journey Time (s/veh) for Various % Scenarios				
	75%	100%	125%	150%	175%
Breezes Road (North) R	0.9	1.1	1.0	1.5	0.5
Breezes Road (South) L	-1.7	-2.4	-3.1	-3.0	-4.4
Pages Road (East) R	2.5	2.5	2.0	2.1	0.9
Pages Road (West) L	-3.0	-3.7	-5.0	-5.3	-6.8
Breezes Road (South) R	0.5	0.6	0.4	0.5	0.3
Breezes Road (North) L	-2.4	-3.5	-3.9	-4.7	-6.6
Pages Road (West) R	0.4	0.2	0.4	0.2	0.2
Pages Road (East) L	-2.0	-2.8	-2.4	-2.9	-4.4

Table 5-10 shows a consistent pattern of a decrease of around 2 to 7 s/veh in left turn journey time and increases of up to 2.5 s/veh in right turn journey time.

Overall there is very little difference in journey times shown between the two different rules using the volumes of Method 2. Right turn journey times increase as expected and left turn journey times decrease. The decrease in left turn journey time gets larger as expected with the incremental increase in right turning vehicles which is logical given that under the changed rule an increase in right turning vehicles is an increase in the flow that has to yield priority to the left turning vehicles.

5.2.3 Queue Lengths Method 1

Figure 5-32 to Figure 5-35 present queue length comparisons for all four right turns at the intersection. All four approaches have dedicated right turn lanes.

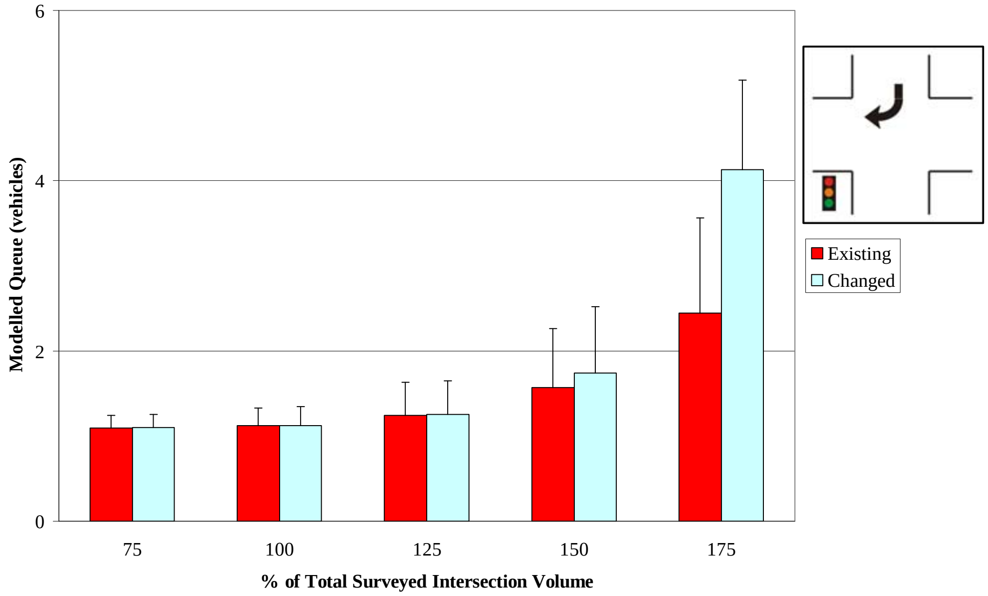


Figure 5-32 - Intersection 2, M1, Breezes Road (North) Right Turn Queue Comparison

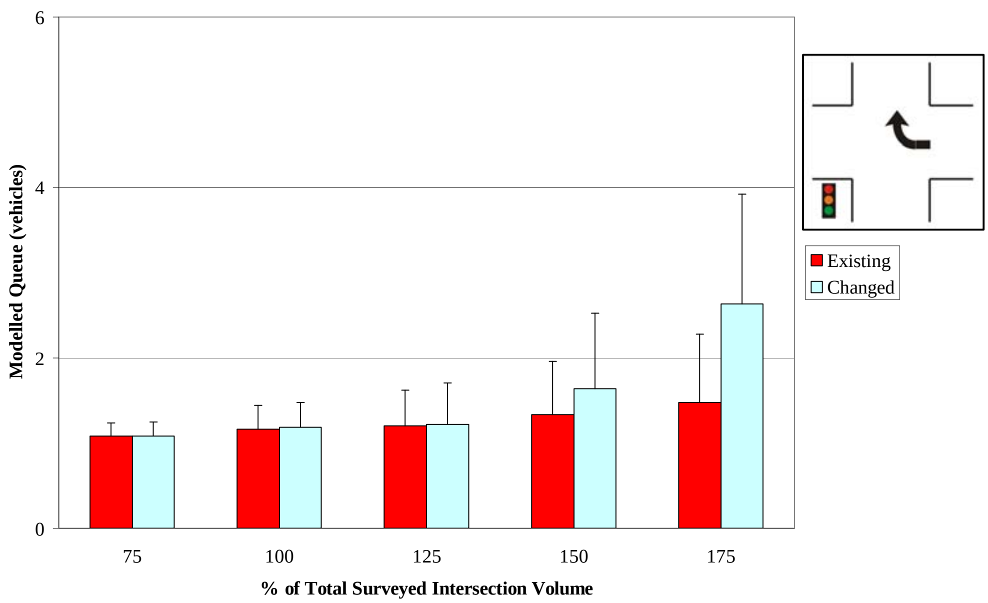


Figure 5-33- Intersection 2, M1, Pages Road (East) Right Turn Queue Comparison

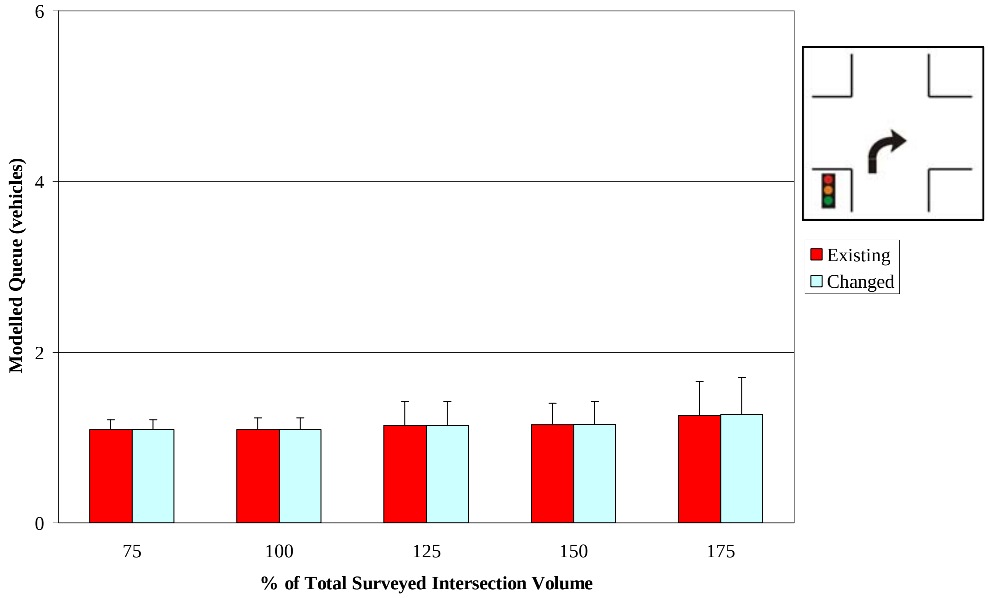


Figure 5-34- Intersection 2, M1, Breezes Road (South) Right Turn Queue Comparison

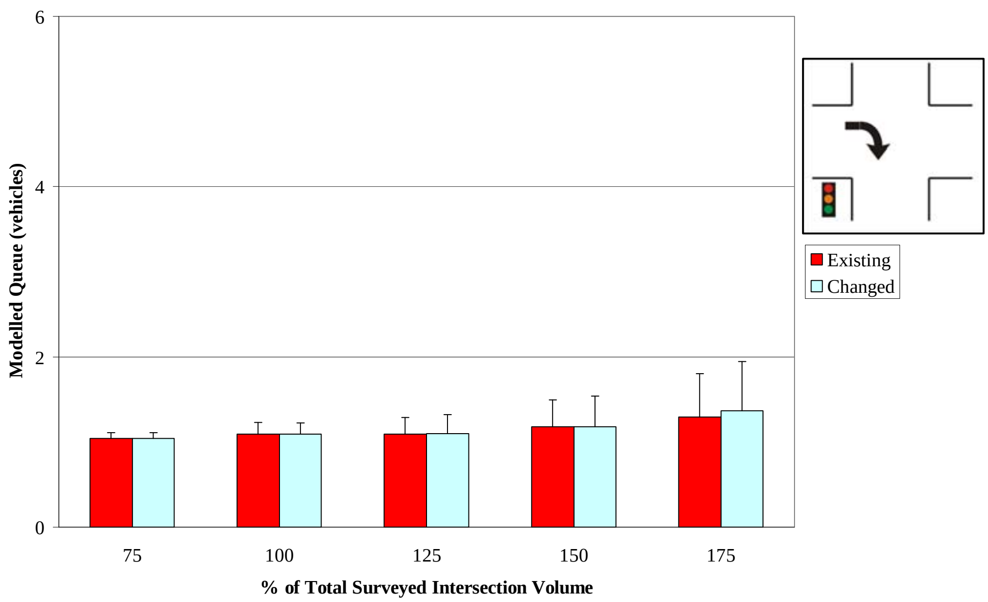


Figure 5-35 - Intersection 2, M1, Pages Road (West) Right Turn Queue Comparison

Figure 5-32 to Figure 5-35 show a consistent pattern of increases in right turn queue length under the changed rule. The size of this increase grows as the total volume through the intersection increases.

Figure 5-36 to Figure 5-39 present queue length comparisons for all lanes accommodating left turns at the intersection. The Breezes Road (South) approach has a dedicated left turn lane whilst all other approaches are shared through and left lanes.

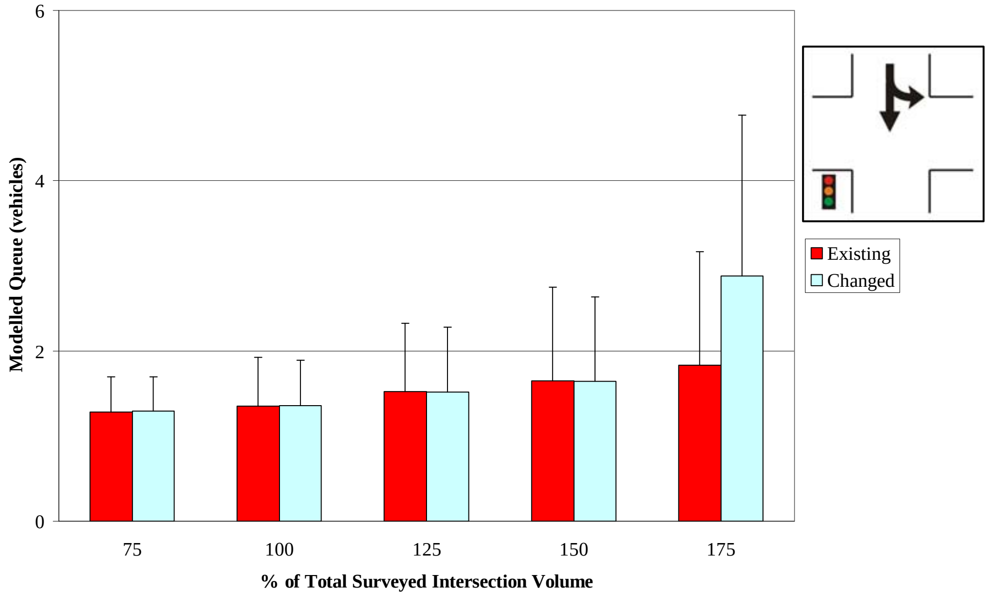


Figure 5-36 - Intersection 2, M1, Breezes Road (North) Shared Through and Left Queue Comparison

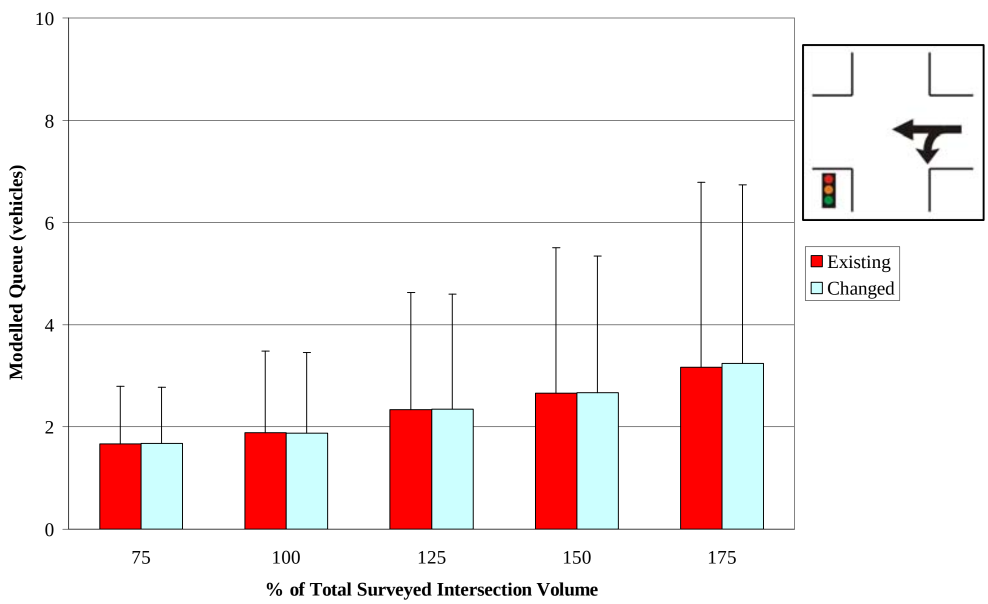


Figure 5-37- Intersection 2, M1, Pages Road (East) Shared Through and Left Queue Comparison

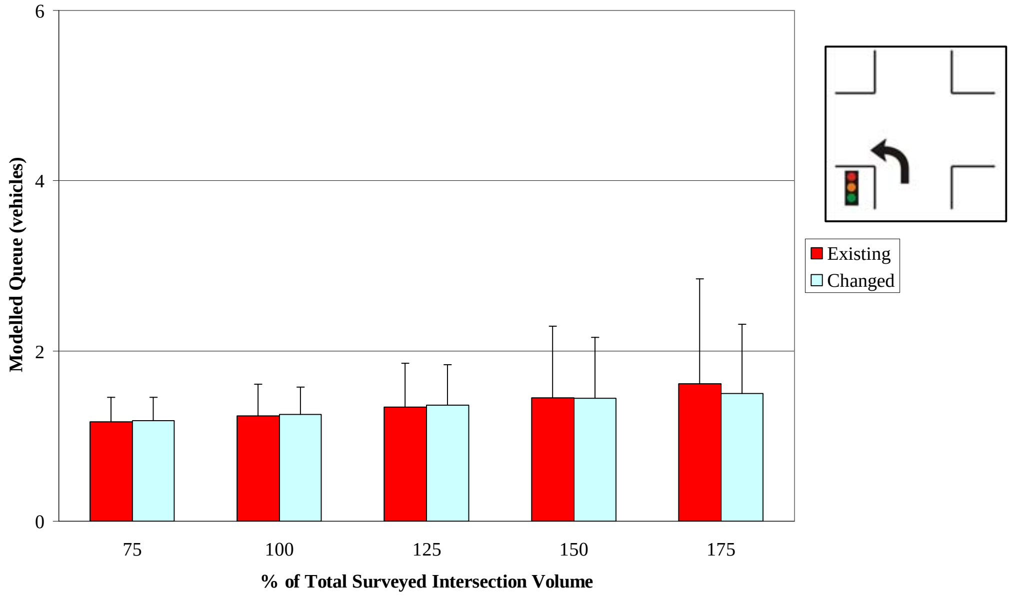


Figure 5-38- Intersection 2, M1, Breezes Road (South) Left Turn Queue Comparison

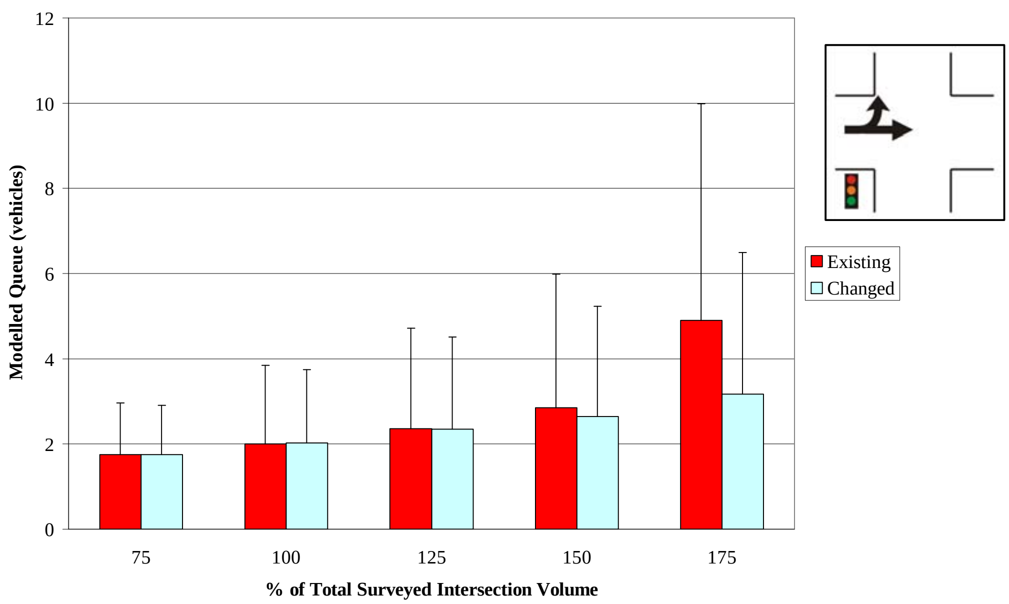


Figure 5-39 - Intersection 2, M1, Pages Road (West) Shared Through and Left Queue Comparison

It is evident that for the 75%, 100%, 125% and 150% scenarios there is very little difference in queue length on any of the approaches. At 175% the result on the Breezes Road (North) approach is counter intuitive as the queue increases following the rule change to near side priority. Observation of the model vehicles in the model and consideration of the model results shows that this is due to the right turn queue on this approach exceeding the length of the right turn lane and creating queuing further back along the approach. On the eastern approach there is very little difference between the two rules. On the southern and western approaches the average and maximum queue lengths decrease following the rule change to near side priority. Table 5-11 summarises the average queue lengths for each volume scenario.

Table 5-11 - Intersection 2, M1, Average Queue Comparison

Approach	Mvt	Average Queue Length (vehicles) for Various % Scenarios									
		75%		100%		125%		150%		175%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Breezes Road (North)	TL	1.3	1.3	1.4	1.4	1.5	1.5	1.7	1.6	1.8	2.9
	R	1.1	1.1	1.1	1.1	1.2	1.3	1.6	1.7	2.4	4.1
Pages Road (East)	TL	1.7	1.7	1.9	1.9	2.3	2.3	2.7	2.7	3.2	3.2
	R	1.1	1.1	1.2	1.2	1.2	1.2	1.3	1.6	1.5	2.6
Breezes Road (South)	L	1.2	1.2	1.2	1.3	1.3	1.4	1.4	1.4	1.6	1.5
	T	1.8	1.8	2.3	2.3	2.8	2.8	3.3	3.2	3.9	3.6
	R	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.3	1.3
Pages Road (West)	TL	1.7	1.7	2.0	2.0	2.4	2.3	2.8	2.6	4.9	3.2
	R	1.0	1.0	1.1	1.1	1.1	1.1	1.2	1.2	1.3	1.4

Overall the results for Method 1 show that the changed rule has very little effect on the shared through and left lanes, offering some small reductions in queue length. Right turn queue lengths increase and on the more critical approaches exceed the currently provided length of right turn lane in some simulations. The size of the increases and decreases grow as the total volume though the intersection increases.

5.2.4 Queue Lengths Method 2

Figure 5-40 to Figure 5-43 present queue length comparisons for all four right turns at the intersection. All four approaches have dedicated right turn lanes.

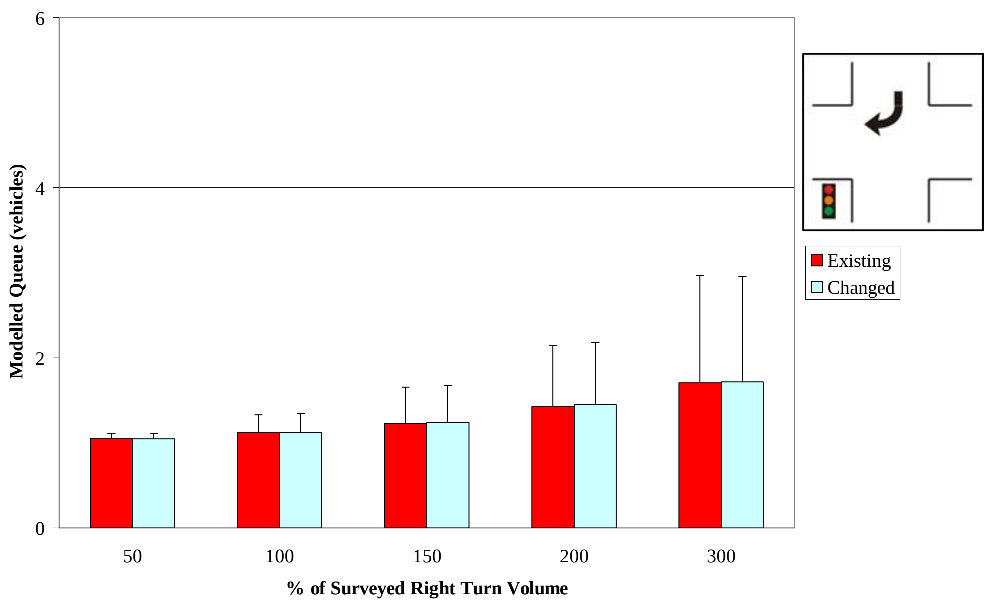


Figure 5-40 - Intersection 2, M2, Breezes Road (North) Right Turn Queue Comparison

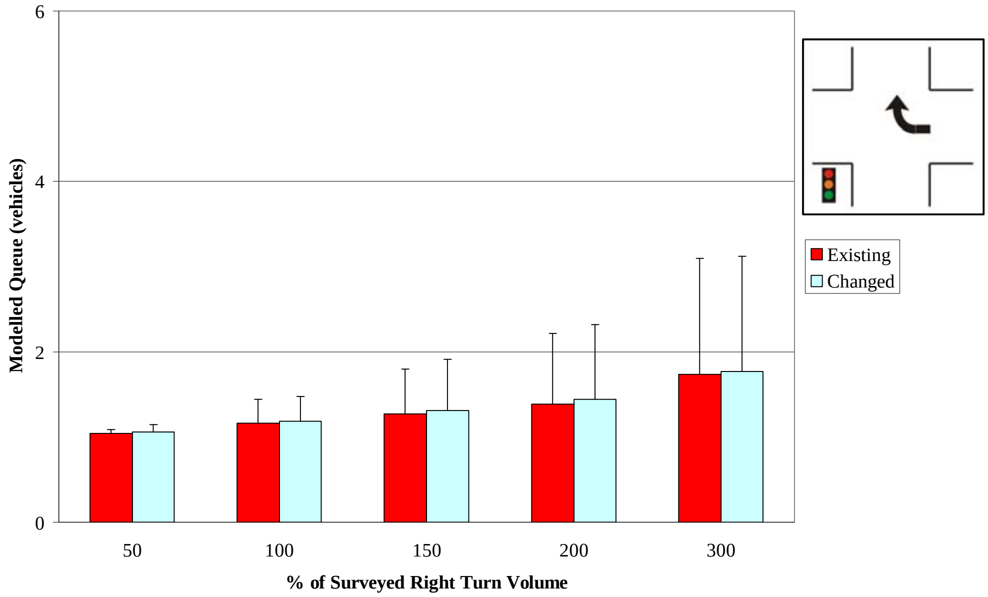


Figure 5-41 - Intersection 2, M2, Pages Road (East) Right Turn Queue Comparison

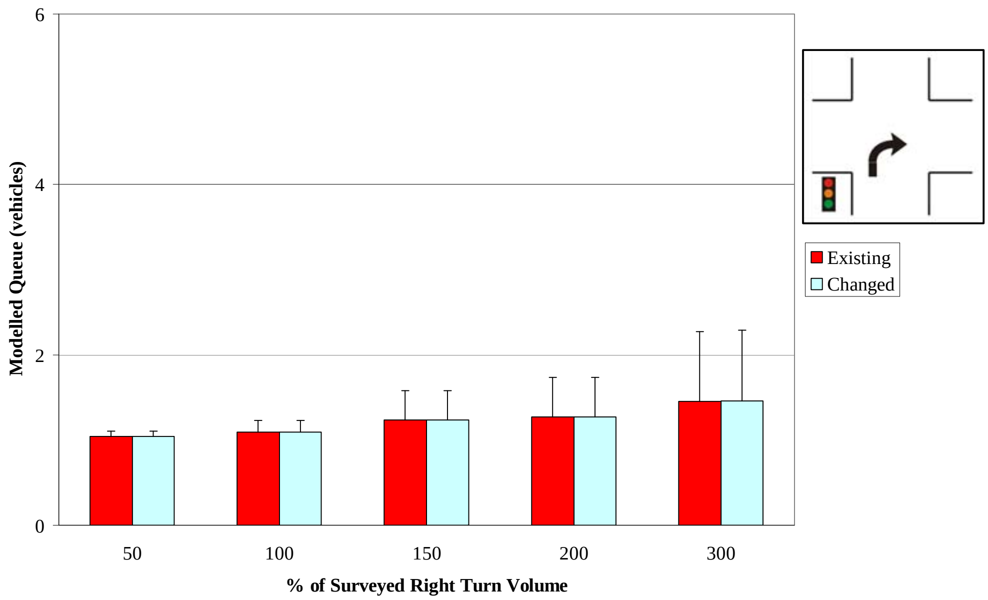


Figure 5-42 - Intersection 2, M2, Breezes Road (South) Right Turn Queue Comparison

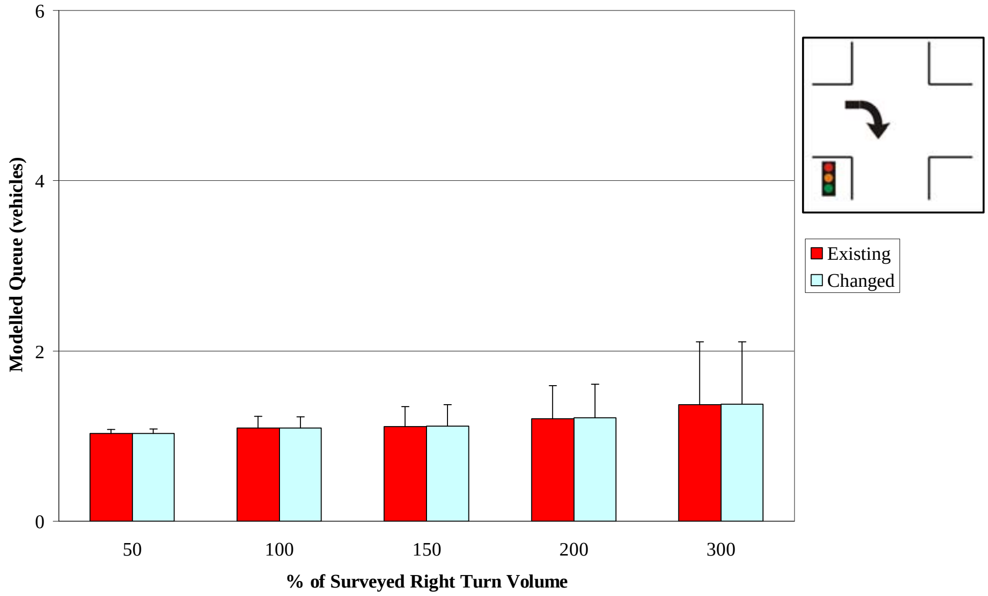


Figure 5-43 - Intersection 2, M2, Pages Road (West) Right Turn Queue Comparison

Figure 5-40 to Figure 5-43 all show that there is very little difference between the queuing in the right turn lanes under the two rules for any volume scenario. Logically, the queue lengths increase as the proportion of right turning vehicles increases.

Figure 5-44 to Figure 5-47 present queue length comparisons for all lanes accommodating left turns at the intersection. The Breezes Road (South) approach has a dedicated left turn lane whilst all other approaches are shared through and left lanes.

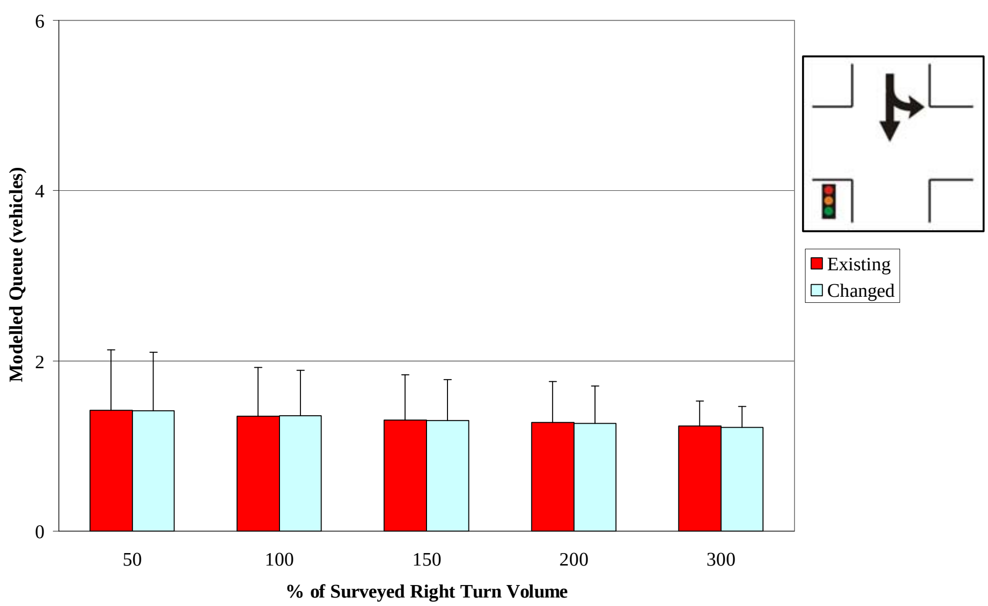


Figure 5-44 - Intersection 2, M2, Breezes Road (North) Shared Through and Left Queue Comparison

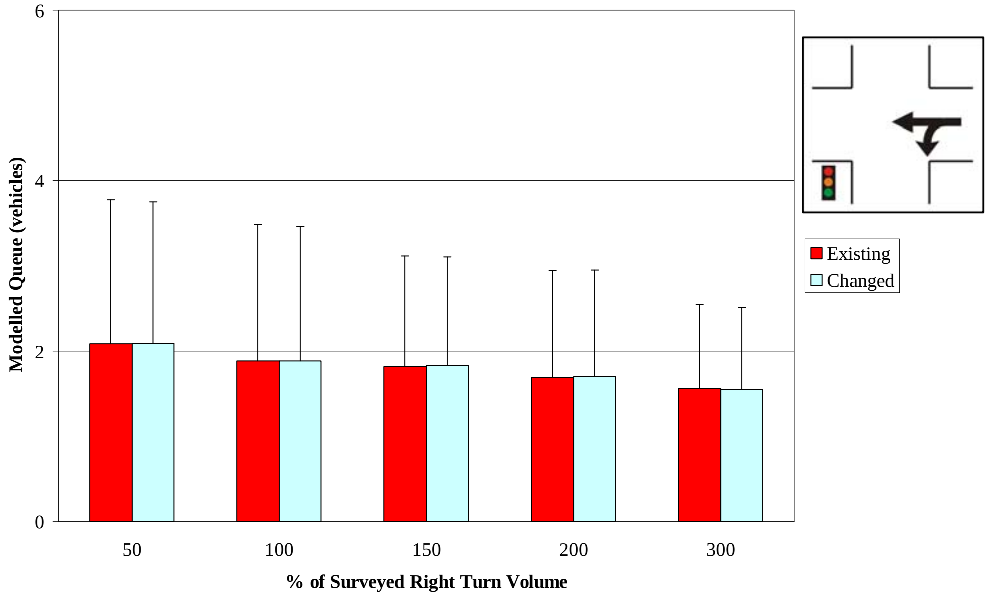


Figure 5-45 - Intersection 2, M2, Pages Road (East) Shared Through and Left Queue Comparison

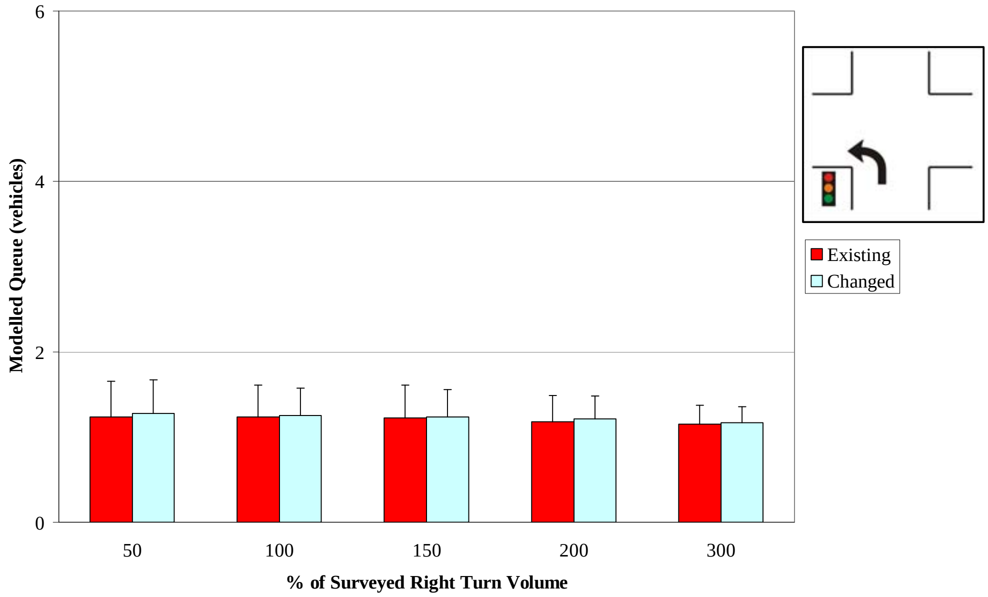


Figure 5-46 - Intersection 2, M2, Breezes Road (South) Left Turn Queue Comparison

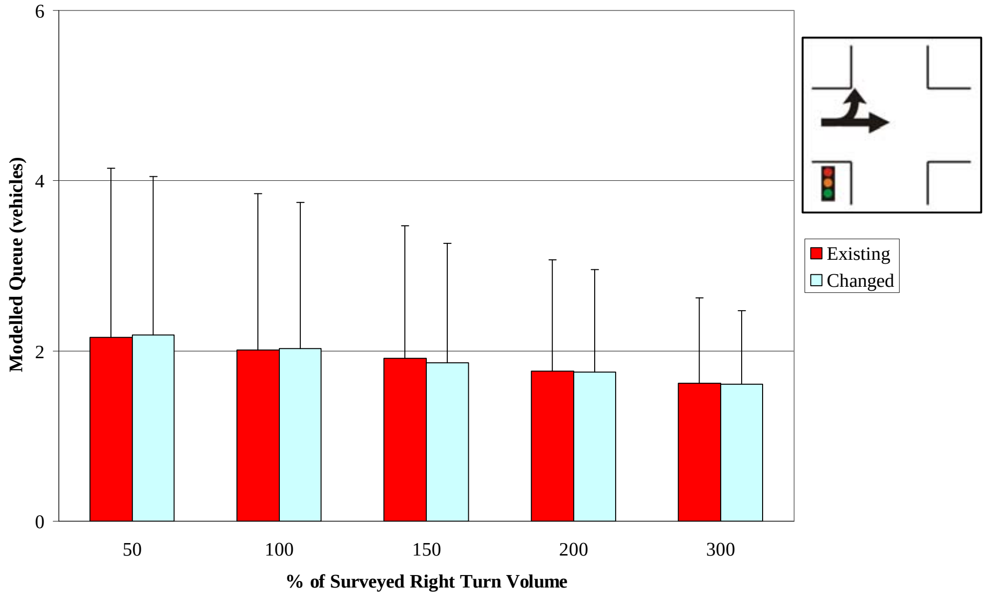


Figure 5-47 - Intersection 2, M2, Pages Road (West) Shared Through and Left Queue Comparison

Figure 5-44 to Figure 5-47 all show that there is very little difference between the queuing in the left and shared through and left lanes under the two rules for any volume scenario. Logically, the queue lengths reduce as the proportion of right turning vehicles increases and all other volumes reduce.

Table 5-12 summarises the average queue lengths for various volume scenarios.

Table 5-12 - Intersection 2, M2, Average Queue Comparison

Approach	Mvt	Average Queue Length (vehicles) for Various % Scenarios									
		50%		100%		150%		200%		300%	
		Ex	**Ch**	**Ex**	**Ch**	**Ex**	**Ch**	**Ex**	**Ch**	**Ex**	**Ch**
Breezes Road (North)	TL	1.4	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.2	1.2
	R	1.1	1.0	1.1	1.1	1.2	1.2	1.4	1.4	1.7	1.7
Pages Road (East)	TL	2.1	2.1	1.9	1.9	1.8	1.8	1.7	1.7	1.6	1.5
	R	1.0	1.1	1.2	1.2	1.3	1.3	1.4	1.4	1.7	1.8
Breezes Road (South)	L	1.2	1.3	1.2	1.3	1.2	1.2	1.2	1.2	1.2	1.2
	T	2.4	2.4	2.3	2.3	2.1	2.1	2.0	2.0	1.7	1.7
	R	1.0	1.0	1.1	1.1	1.2	1.2	1.3	1.3	1.5	1.5
Pages Road (West)	TL	2.2	2.2	2.0	2.0	1.9	1.9	1.8	1.8	1.6	1.6
	R	1.0	1.0	1.1	1.1	1.1	1.1	1.2	1.2	1.4	1.4

Table 5-12 shows very little difference between the two rules for any of the volume scenarios tested under Method 2.

5.2.5 Discussion

The intersection of Breezes Road/Pages Road has generally shown results that seem intuitively sensible, being increases in right turn journey time and queue length and corresponding decreases in left turn journey time and queue length.

The pattern that emerges is that the increase in right turn journey time and queue length and the decrease in left turn journey time and queue length are similar in size at lower volume scenarios but as the total volume through the intersection increases the increase in journey time incurred by right turning vehicles starts to exceed the reduction offered to left turning vehicles.

At the Method 1 175% scenario the intersection operation begins to break down and issues such as inadequate length of some right turn lanes and consequential poor operation of approaches begin to arise. At this volume level the existing rule is shown to be slightly more efficient than the changed rule.

The analysis suggests that the impacts of a rule change to near side priority at this intersection could include the need for dedicated right turn signal phases and longer right turn lanes.

The results from the Method 2 analysis show a similar general pattern although the differences between the two rules are generally smaller. For the remaining intersections the Method 2 results are not presented in the main body of the thesis but are presented in Appendices A3 to A12.

5.3 Intersection 3: Marshland Road/The Palms

5.3.1 Journey Times Method 1

Table 5-13 summarises the average journey time for all movements for each volume scenario.

Table 5-13 - Intersection 3, M1, Average Journey Time Comparison

Approach	Mvt	Average Journey Time (s/veh) for Various % Scenarios									
		75%		100%		125%		150%		175%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Marshland Road (North)	L	47	43	48	43	50	43	50	43	51	44
	T	51	51	52	52	52	52	53	52	54	53
The Palms (East)	L	19	19	20	20	22	22	24	24	26	28
	R	41	41	40	40	42	42	43	43	45	46
Marshland Road (South)	T	22	22	23	23	23	23	23	23	23	24
	R	26	27	27	30	28	34	31	40	34	56
Total	All	33	33	34	34	35	35	36	37	38	40

As expected, the right turn journey time increases and the left turn journey time decreases as a result of the rule change to near side priority under all scenarios. Across all movements the existing rule results in an average journey time that is up to 2 s/veh shorter than the changed rule.

Table 5-14 summarises the changes in the right and left turn journey times off Marshland Road.

Table 5-14 – Intersection 3, M1, Right and Left Turn Journey Time Changes

Movement	Change in Journey Time (s/veh) for Various % Scenarios				
	75%	100%	125%	150%	175%
Marshland Road Right Turn	1	3	6	9	22
Marshland Road Left Turn	-4	-5	-7	-7	-7

Table 5-14 shows that as the total volume through the intersection increases the right turn journey time increases by up to three times more than the left turn journey time decreases.

5.3.2 *Queue Lengths Method 1*

Table 5-15 summarises the average queue lengths for various volume scenarios.

Table 5-15 - Intersection 3, M1, Average Queue Comparison

Approach	Mvt	Average Queue Length (vehicles) for Various % Scenarios									
		75%		100%		125%		150%		175%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Marshland Road (North)	L	1.1	1.1	1.3	1.2	1.4	1.2	1.5	1.3	1.7	1.3
	T	1.4	1.4	1.7	1.6	1.9	1.9	2.2	2.1	2.5	2.4
The Palms (East)	L	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.4	1.6	1.6
	R	1.5	1.5	1.6	1.6	2.0	2.0	2.4	2.4	3.0	3.1
Marshland Road (South)	T	1.2	1.2	1.4	1.4	1.5	1.5	1.6	1.7	1.8	2.0
	R	1.1	1.2	1.2	1.3	1.4	1.8	1.6	2.3	2.0	4.2

Overall the queue comparison shows a similar pattern as the journey time comparison where the right turn queue increases under the rule change to near side priority and the left turn queue decreases. The increase in the right turn queue is larger than the corresponding decrease for the left turn. There is little difference on the approach from The Palms which is expected given the signal timings have not changed.

5.3.3 *Discussion*

The analysis has shown that the intersection of Marshland Road/The Palms, which is a three-arm signalised intersection with separate left and right turn lanes and a dedicated right turn phase, operates more efficiently under the existing rule than it would under the changed rule for almost all of the tested scenarios. The difference is however quite small.

The analysis suggests that possible implications of a rule change to near side priority at this intersection could include the need for a longer right turn lane on Marshland Road.

5.4 Intersection 4: Bealey Avenue/Colombo Street

5.4.1 Journey Times Method 1

Table 5-16 summarises the average journey time for all movements for each volume scenario.

Table 5-16 - Intersection 4, M1, Average Journey Time Comparison

Approach	Mvt	Average Journey Time (s/veh) for Various % Scenarios									
		75%		100%		125%		150%		175%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Colombo Street (North)	L	81	80	82	81	83	81	85	84	96	96
	T	84	84	86	86	88	88	93	93	106	109
	R	89	89	92	92	92	92	97	96	109	111
Bealey Avenue (East)	L	141	138	142	138	144	139	145	140	145	140
	T	137	137	137	137	138	138	139	139	141	141
	R	151	153	161	169	255	370	888	1165	1613	1869
Colombo Street (South)	L	56	54	57	55	58	57	59	57	62	58
	T	56	56	57	57	58	59	60	60	63	63
	R	60	60	60	60	62	62	65	65	66	66
Bealey Avenue (West)	L	145	142	146	142	147	143	147	143	147	144
	T	141	141	141	141	141	141	142	142	143	143
	R	147	147	148	148	151	151	156	156	161	161
Total	All	128	128	129	129	135	141	169	183	207	219

The analysis show that there is very little difference in the right turn journey times on the north, south and west approaches. The right turn from Bealey Avenue (East) is clearly the most critical movement and very sensitive to increases in total intersection volume. This intersection has no dedicated right turn signal phases.

Average journey times that reach in the order of 1,600 s/veh (around 27 minutes) indicate that this approach has essentially broken down. Journey times of this size would not occur in a real network as vehicles would re-route before such extreme delays eventuated. They show that the existing rule does operate more efficiently than the changed rule for this right turn movement. Site observations indicate that many right turning vehicles rely on the amber and red time to complete their turn. This feature of the intersection operation can be modelled in Paramics to some extent but vehicles using red time cannot be modelled. Therefore it appears to be under-represented in Paramics compared to its frequency of occurrence in reality. Also the Paramics model represents the intersection in complete isolation whereas in reality this intersection operates with other signalised intersections nearby which cause platoons of vehicles and therefore create gaps for turning vehicles to utilise.

All the left turn movements show a consistent pattern of a decrease in journey time that remains relatively consistent regardless of the total volume through the intersection.

Table 5-17 presents a comparison for the increase or decrease in journey time for each right turn and the opposing left turn.

Table 5-17 - Intersection 4, M1, Right and Left Turn Journey Time Changes

Movement	Change in Average Journey Time (s/veh) for Various % Scenarios				
	75%	100%	125%	150%	175%
Colombo Street (North) R	-0.0	-0.2	0.5	-0.4	1.3
Colombo Street (South) L	-1.6	-1.6	-1.8	-2.2	-3.4
Bealey Avenue (East) R	2.0	8.0	114.1	277.2	255.8
Bealey Avenue (West) L	-2.9	-3.6	-4.2	-3.7	-3.6
Colombo Street (South) R	0.0	0.0	-0.0	0.3	0.1
Colombo Street (North) L	-1.0	-0.9	-1.4	-1.5	-0.1
Bealey Avenue (West) R	-0.1	-0.0	0.3	0.2	-0.2
Bealey Avenue (East) L	-3.3	-3.6	-4.4	-4.6	-5.4

Table 5-17 shows that journey times for all the left turn movements decrease by between 0.1 and 5.4 s/veh. The change generally increases slowly as the total volume through the intersection increases. /he right turn journey times on the north, south and west approaches are not significantly affected whereas the east approach is dramatically affected and performs better under the existing rule than the changed rule.

5.4.3 Queue Lengths Method 1

Table 5-18 summarises the average queue lengths for various volume scenarios.

Table 5-18 - Intersection 4, M1, Average Queue Comparison

Approach	Mvt	Average Queue Length (vehicles) for Various % Scenarios									
		75%		100%		125%		150%		175%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Colombo Street (North)	L	1.1	1.1	1.1	1.1	1.1	1.2	1.3	1.3	1.4	1.4
	TR	1.4	1.4	1.7	1.7	1.9	1.9	2.2	2.2	2.5	2.5
Bealey Avenue (East)	L	1.1	1.1	1.1	1.1	1.2	1.1	1.3	1.3	1.3	1.3
	T	1.6	1.6	1.9	1.9	2.2	2.3	2.6	2.6	2.9	2.9
	T	1.3	1.3	1.5	1.5	1.7	1.7	2.2	2.2	2.7	2.7
	T	1.1	1.1	1.3	1.3	3.6	7.0	31.4	44.4	73.4	87.7
	R	1.3	1.4	1.7	1.9	3.8	4.6	5.3	5.4	5.5	5.6
Colombo Street (South)	L	1.3	1.3	1.5	1.5	1.7	1.7	1.9	1.9	2.2	2.1
	TR	1.5	1.5	1.7	1.7	1.9	1.9	2.2	2.2	2.5	2.5
Bealey Avenue (West)	L	1.1	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.4	1.3
	T	1.7	1.7	2.1	2.1	2.4	2.4	2.7	2.7	3.1	3.1
	T	1.3	1.3	1.5	1.5	1.7	1.7	2.1	2.1	2.4	2.4
	T	1.2	1.2	1.4	1.4	1.5	1.6	1.7	1.7	2.1	2.1
	R	1.1	1.1	1.2	1.2	1.3	1.3	1.5	1.5	1.8	1.8

Table 5-18 shows that the left turn queue lengths are very similar under both rules with some scenarios showing a small reduction under the changed rule.

The right turn queue lengths show a similar pattern in reverse, with similar queue lengths and some scenarios showing a small increase under the changed rule.

The right turn from Bealey Avenue (East) shows nothing of note in the right lane itself. However the queuing in the adjacent through lane increased significantly as the total volume through the intersection increases. As with the results observed for the journey times for this movement, the existing rule results in shorter queues.

5.4.2 Discussion

The four-arm signalised intersection of Bealey Avenue and Colombo Street which operates with a two-phase signal arrangement operates with slightly better journey times and queue lengths under the existing rule when compared to the changed rule.

Right turn movements from the Bealey Avenue (East) approach were shown to be difficult and the journey time and queue lengths increased dramatically with both increasing total volume and increased proportion of right turning vehicles. Under the changed rule, the increases were larger than with the existing rule. Therefore at this intersection a rule change to near side priority would exaggerate an existing issue and possibly bring forward the need for a right turn phase and potentially a longer right turn lane.

The analysis suggests that at this intersection a right turn phase from Bealey Avenue (East) may already be justified, or be close to being justified, and this would be accentuated following a rule change to near side priority.

Other right turn movements were affected slightly, showing slightly longer queue lengths and journey times. On both Colombo Street approaches the right turning vehicles share a lane with through vehicles and as the right turn becomes more difficult the through movement would also be affected. This was not shown to be significant at the tested volume combinations. Were it to become significant a possible impact would be that the lane configuration could be better as a dedicated right turn lane and a shared through and left lane.

The left turn movements at the intersection were generally not very sensitive to a rule change to near side priority and showed very slight decreases in journey time and queue length.

The surveyed traffic volumes at this intersection, which are used as the start point for the tested volume scenarios, show that the through movement on both Bealey Avenue approaches is around 800-900 vehicles per hour, distributed across the three provided through lanes. The volume of vehicles turning left off the Bealey Avenue approaches is around 10% of this.

On this type of multi-lane arterial road with such hourly volumes it could be that the impact opposing left and right turning vehicles have on each other is minimal compared to the impact the opposing through volume has on the right turning vehicles attempting to turn across it. This would support the results of this analysis that show only small differences in journey times and queues under each rule.

5.5 Intersection 5: Main North Road/Prestons Road

5.5.1 Journey Times Method 1

Table 5-19 summarises the average journey times for all movements for each volume scenario.

Table 5-19 - Intersection 5, M1, Average Journey Time Comparison

Approach	Mvt	Average Journey Time (s/veh) for Various % Scenarios									
		75%		100%		125%		150%		175%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Main North Road (North)	L	65	60	67	61	69	63	71	63	77	67
	T	57	57	59	58	60	59	62	60	66	63
Prestons Road (East)	L	60	60	59	59	60	60	62	61	61	61
	R	79	79	76	76	80	80	78	78	78	79
Main North Road (South)	T	40	40	40	40	41	41	42	42	44	45
	R	53	56	61	63	69	72	76	79	83	84
Total	All	51	50	52	51	53	53	55	54	58	56

It is evident from the analysis that with the changed rule, as expected, that the right turn journey increases and the left turn journey time decreases. Table 5-20 presents a summary of the increase or decrease in journey time for these two movements as a result of the rule change to near side priority.

Table 5-20 – Intersection 5, M1, Right and Left Turn Journey Time Changes

Movement	Change in Journey Time (s/veh) for Various % Scenarios				
	75%	100%	125%	150%	175%
Main North Rd Right Turn	3	3	3	3	1
Main North Rd Left Turn	-6	-6	-6	-7	-9

Table 5-20 shows that the increase in right turn journey time as a result of the rule change to near side priority is less than the decrease for the left turn. In terms of the overall average journey time for all movements, the changed rule proves to be slightly more efficient at this intersection.

5.5.2 Queue Lengths Method 1

Table 5-21 summarises the average queue lengths for all movements for each volume scenario.

Table 5-21 - Intersection 5, M1, Average Queue Comparison

Approach	Mvt	Average Queue Length (vehicles) for Various % Scenarios									
		75%		100%		125%		150%		175%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Main North Road (North)	LT	2.8	2.9	3.6	3.7	4.5	4.7	5.4	5.6	6.8	6.7
	T	2.7	2.7	3.5	3.5	4.4	4.4	5.4	5.3	6.9	6.4
Prestons Road (East)	L	1.4	1.4	1.5	1.5	1.7	1.7	1.9	1.9	2.2	2.2
	R	1.7	1.7	1.9	1.9	2.4	2.4	2.6	2.6	2.9	3.0
Main North Road (South)	T	2.3	2.3	2.9	2.9	3.6	3.6	4.1	4.1	5.0	5.0
	T	1.5	1.5	1.8	1.8	2.2	2.3	3.1	3.1	4.2	4.3
	R	1.3	1.4	1.8	1.9	2.3	2.4	2.8	2.9	3.4	3.5

Table 5-21 illustrates that there is very small increase in the average right turn length on Main North Road. In the shared through and left lane there is also on a small difference in average queue however the graph illustrates that the existing rule gives a longer maximum queue.

5.5.3 Discussion

The analysis has shown that the intersection of Main North Road/Prestons Road is a three-arm signalised intersection with a separation right turn lane and a shared through and left lane, and a dedicated right turn phase would be affected only slightly by a rule change to near side priority.

Because of the presence of a dedicated right turn phase only a proportion of right turning vehicles move through the intersection using priority rules. Therefore although some effects of the rule change to near side priority can be seen in the form of increased right turn lengths and journey times and corresponding reductions for the left turn, these effects are not dramatic.

There is some evidence in the Method 1 testing that the changed rule results in overall improved journey times through the intersection. Reviewing the average journey times for each movement shows that the southbound through movement journey time improves under the changed rule. This movement shares a through and left lane and this improvement could be the result of the left turn becoming unopposed and interfering less with the through movement.

The analysis suggests that possible implications of a rule change to near side priority at this intersection would be minimal. There could be benefits for the Main North Road northern approach where the interference of left turning vehicles is reduced and the through lanes operate more efficiently. This raises the question of lane utilisation which is addressed by the further testing in Section 6 of this thesis.

Although the volumes used in this testing did not reach levels that caused high right turn journey times, the right turn from Main North Road could become more difficult and the length of the right turn bay could become an issue should such volumes eventuate.

5.6 Intersection 6: Innes Road/Papanui Road

5.6.1 Journey Times Method 1

Table 5-22 summarises the average journey time for all movements for each volume scenario.

Table 5-22 - Intersection 6, M1, Average Journey Time Comparison

Approach	Mvt	Average Journey Time (s/veh) for Various % Scenarios									
		75%		100%		125%		150%		175%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Papanui Road (North)	L	61	58	63	59	66	62	91	67	129	103
	T	61	61	62	62	65	65	88	69	126	105
	R	71	73	81	84	93	103	201	160	418	175
Innes Road (East)	L	111	107	115	109	120	113	143	128	386	372
	T	105	105	107	107	109	108	129	124	374	370
	R	103	103	105	106	111	111	123	121	356	355
Papanui Road (South)	L	156	154	159	156	161	158	237	426	462	615
	T	163	163	165	165	168	168	242	435	467	626
	R	167	169	179	185	216	296	738	1235	1003	1413
Innes Road (West)	L	100	96	107	99	122	111	197	186	305	296
	T	89	89	91	91	101	102	177	176	287	285
	R	82	82	83	83	85	86	138	136	220	219
Total	All	107	107	110	110	115	118	179	242	332	378

Table 5-23 presents a comparison for the increase or decrease in journey time for each right turn and the opposing left turn.

Table 5-23 - Intersection 6, M1, Right and Left Turn Journey Time Changes

Movement	Change in Average Journey Time (s/veh) for Various % Scenarios				
	75%	100%	125%	150%	175%
Papanui Road (North) R	2.1	3.6	9.8	-40.6	-242.3
Papanui Road (South) L	-2.2	-2.7	-3.0	188.8	153.3
Innes Road (East) R	0.2	0.6	0.5	-2.0	-1.6
Innes Road (West) L	-4.5	-8.2	-10.0	-11.3	-9.3
Papanui Road (South) R	1.9	5.9	80.7	496.7	410.2
Papanui Road (North) L	-3.2	-3.6	-4.0	-23.9	-25.6
Innes Road (West) R	0.3	0.1	0.8	-1.4	-1.1
Innes Road (East) L	-3.4	-6.0	-7.3	-14.6	-13.8

The analysis shows that on the North and East approaches, under the higher volume scenarios, the changed rule results in shorted right turn journey times. This is counterintuitive and is due to the opposing approaches, from the South and West becoming blocked by overflowing right turn lanes. An example of this type of blocking, which also occurred at Intersection 2 (Breezes Road/Pages Road) was presented in Figure 5-17 (Page 5). The intersection is operating in a heavily congested manner as evidenced by the high journey times on the graphs.

The analysis has shown a mixture of some increases and some decreases in left turn journey time. When the intersection is operating without blocked approaches there is a general pattern of a reduction in left turn journey times. However when the right turn lanes become full some approaches become blocked and all movements on the approach are affected.

Table 5-22 and Table 5-23 show that for the first three scenarios, before the intersection operation breaks down, there is a trend of right turn journey time increasing by more than the left turn journey time decreases.

The 150% and 175% scenarios are too much for the intersection which breaks down under the applied traffic volumes. Particular issues are highlighted with the right turns become more difficult particularly from the south approach.

Site observations at this intersection indicate that many vehicles rely on the amber and red time to complete their turn. This is particularly true during peak periods of the day and for vehicles turning across high volume movements, for example the northbound flow on Papanui Road during the weekday evening peak. This appears to not be represented as much in Paramics as it occurs in reality. Even at manageable volumes this results in Paramics underestimating the actual capacity of filtering right turns.

As a result of this the model suggests that measures such as right turn signal phases and longer right turn lanes may be required before the actual on-street operation would suggest this.

5.6.2 Queue Lengths Method 1

Table 5-24 summarises the average queue lengths for each volume scenario.

Table 5-24 - Intersection 6, M1, Average Queue Comparison

Approach	Mvt	Average Queue Length (vehicles) for Various % Scenarios									
		75%		100%		125%		150%		175%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Papanui Road (North)	L	1.2	1.2	1.2	1.3	1.4	1.4	1.6	1.4	1.8	1.7
	T	3.2	3.2	4.5	4.5	5.9	5.9	10.8	7.7	17.0	12.6
	R	1.1	1.1	1.2	1.2	1.4	1.5	3.5	3.4	8.3	3.7
Innes Road (East)	L	1.3	1.3	1.5	1.4	1.6	1.5	1.9	1.7	2.0	1.9
	T	3.1	3.1	4.2	4.2	5.3	5.3	9.8	8.8	24.4	24.0
	R	1.5	1.5	1.8	1.8	2.2	2.2	3.0	2.9	4.5	4.6
Papanui Road (South)	L	1.2	1.3	1.3	1.3	1.4	1.4	1.6	1.5	1.7	1.5
	T	3.3	3.3	4.5	4.5	5.7	5.6	11.2	19.5	19.9	29.1
	R	1.2	1.2	1.5	1.6	2.6	5.3	19.8	30.6	25.9	35.6
Innes Road (West)	L	1.2	1.2	1.3	1.3	1.5	1.4	1.6	1.5	1.8	1.7
	T	3.3	3.3	4.3	4.3	6.3	6.3	11.5	11.3	23.5	23.3
	R	1.3	1.2	1.4	1.4	1.5	1.5	1.7	1.6	2.0	2.1

The performance of the intersection is influenced by the South approach where the right turn queue increases sharply with the increased traffic volumes. Under the changed rule this increase is greater.

When the left turn queue lengths are not affected by blocked approaches, as described in Section 5.6.1 on journey times, there is a trend of a very small decrease in average queue length.

5.6.3 Discussion

The testing undertaken on the intersection of Innes Road/Papanui Road which is a four-arm signalised intersection where all approaches have three lanes for left turn, through and right turn movements has shown that a rule change to near side priority will affect the performance of the right turn movements.

The testing has highlighted that right turns, particularly those crossing high volume through movements may become significantly more difficult following a rule change to near side priority. The testing has also highlighted that Paramics underestimates the capacity of such right turns by not reflecting the use drivers make of the amber and red time, particularly in congested periods.

As left turn and through movements are allocated their own lanes there is minimal effect on these movements except when right turn queues exceed the available storage.

The testing suggests that the practical implications of a rule change to near side priority at this intersection could include the need for longer right turn bays or introduction of right turn signal phases.

5.7 Intersection 7: Blenheim Road/Matipo Street

5.7.1 Journey Times Method 1

Table 5-25 summarises the average journey time for all movements for each volume scenario.

Table 5-25 - Intersection 7, M1, Average Journey Time Comparison

Approach	Mvt	Average Journey Time (s/veh) for Various % Scenarios									
		75%		100%		125%		150%		175%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Matipo Street (North)	L	57	55	59	57	59	57	60	58	79	123
	T	55	55	55	55	56	56	57	58	75	123
	R	62	62	68	69	77	79	106	122	161	279
Blenheim Road (East)	L	86	86	87	87	89	89	92	91	96	95
	T	85	85	86	86	87	87	89	89	90	90
	R	86	86	86	86	89	88	93	92	99	98
Matipo Street (South)	L	52	50	54	50	64	53	96	54	180	72
	T	50	50	51	51	53	52	73	53	141	71
	R	61	61	66	66	76	76	124	110	271	202
Blenheim Road (West)	L	69	69	70	70	72	72	79	79	110	113
	T	88	88	89	89	91	91	100	98	129	128
	R	94	94	105	106	181	184	593	585	1032	1010
Total	All	74	74	76	76	82	81	108	103	155	149

Table 5-25 shows that overall there is very little difference between the two rules, particularly at the volume scenarios around 100%. As the total volume through the intersection is increased to 175% of the surveyed volume the intersection operation breaks down as shown by the average journey times reaching around 1,000 s/veh.

Table 5-26 presents a summary of the increase or decrease in journey time for these two movements as a result of the rule change to near side priority.

Table 5-26 - Intersection 7, M1, Right and Left Turn Journey Time Changes

Movement	Change in Average Journey Time (s/veh) for Various % Scenarios				
	75%	100%	125%	150%	175%
Matipo Street (North) R	0.1	0.1	1.3	16.5	117.7
Matipo Street (South) L	-2.5	-3.4	-10.7	-41.7	-108.2
Matipo Street (South) R	-0.1	-0.2	-0.9	-14.1	-69.5
Matipo Street (North) L	-2.0	-2.0	-2.2	-1.9	43.5

Table 5-26 shows that at higher volumes there are some significant changes however these are due to wider issues such as blocked approaches. For example, on Matipo Street (South) there is a reduction in right turn journey time. This is due to the greater difficulty right turning vehicles on the Matipo Street (North) approach experience. The queue on this approach exceeds the capacity of the right turn lane, thereby blocking any through or left turning vehicles accessing their lanes. With the south approach blocked, vehicles travelling from the north approach can move through unopposed. This is illustrated in Figure 5-48.

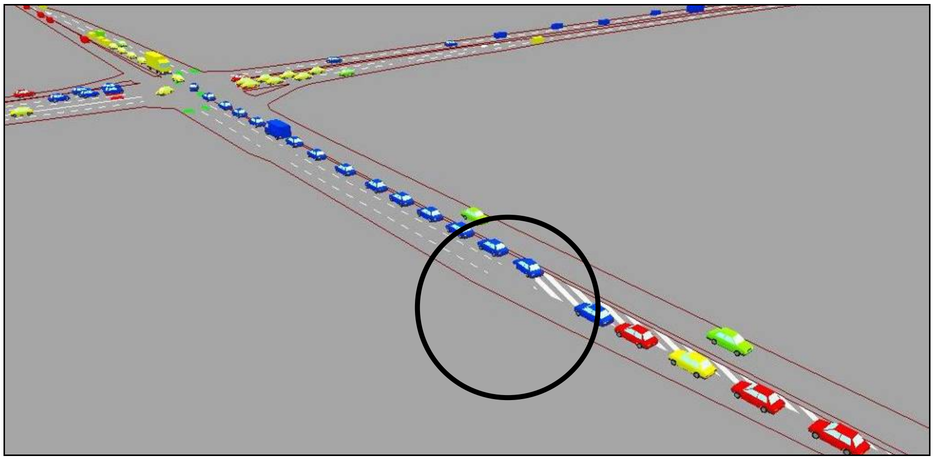


Figure 5-48 - Blocking of Left and Through Lanes Viewed from Matipo Street (North)

On the Matipo Street (North) approach, under the volume scenarios where the intersection is still functioning, there is an increase in right turn journey time observed which is greater than the corresponding decrease in left turn journey time. Overall there is very little difference between the two rules in terms of the average journey time for all movements.

5.7.2 Queue Lengths Method 1

Table 5-27 summarises the average queue lengths for each volume scenario.

Table 5-27 - Intersection 7, M1, Average Queue Comparison

Approach	Mvt	Average Queue Length (vehicles) for Various % Scenarios									
		75%		100%		125%		150%		175%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Matipo Street (North)	L	1.3	1.3	1.5	1.5	1.6	1.6	1.7	1.8	4.0	7.8
	T	2.1	2.1	2.6	2.6	3.2	3.2	3.8	3.8	5.1	5.5
	R	1.4	1.4	1.7	1.7	2.2	2.3	3.5	3.7	6.9	10.6
Blenheim Road (East)	L	1.0	1.0	1.1	1.1	1.2	1.2	1.4	1.3	1.6	1.6
	T	2.9	2.9	3.7	3.7	4.3	4.2	4.9	4.9	5.5	5.6
	T	2.2	2.2	2.9	2.9	3.7	3.7	4.5	4.6	5.2	5.2
	R	1.2	1.2	1.4	1.4	1.6	1.6	1.8	1.7	2.1	2.1
Matipo Street (South)	L	1.5	1.5	1.8	1.8	2.3	2.1	3.9	2.5	14.0	4.1
	T	1.8	1.8	2.2	2.2	2.8	2.7	4.4	3.3	8.5	4.1
	R	1.4	1.4	1.7	1.7	2.2	2.1	3.9	3.7	10.2	9.3
Blenheim Road (West)	L	1.0	1.0	1.1	1.1	1.1	1.1	1.2	1.2	1.3	1.3
	T	2.3	2.3	3.0	3.1	3.8	3.8	4.5	4.5	5.2	5.2
	T	1.9	1.9	2.4	2.4	3.0	2.9	9.7	9.7	28.2	27.3
	R	1.4	1.4	1.9	1.9	3.5	3.3	8.4	8.4	10.1	10.0

As discussed above the operation of the intersection is affected by blocked approaches and therefore the 175% scenario gives rise to some results that require careful interpretation. Review of the results of the other scenarios, where the intersection is operating reasonably well show that on Matipo Street (North) the right turn queue length increases slightly and there is very little change to the left turn queue length. On Matipo Street (South) there is also an increase in right turn queue length and a more obvious reduction in left turn queue length.

5.7.3 Discussion

The intersection of Blenheim Road/Matipo Street is a four-arm signalised intersection where the Blenheim Road approaches have two through lanes, a right turn lane and give-way controlled left turn lanes. The Matipo Street approaches have left, through and right lanes. A dedicated right turn phase is provided for vehicles turning right from Blenheim Road (East).

As the left turns from both Blenheim Road approaches are controlled by give-way signs, these turns and the right turns off Blenheim Road are not affected by which rule is applied. This was discussed previously in Section 2.9.2.

The testing has shown that the Matipo Street approaches, which are affected by the rule controlling left and right turn priority, operate differently under each rule. With the changed rule right turns from both approaches become harder and journey times and queue lengths increase. There is some improvement for left turning vehicles however this is smaller, both in terms of journey time and queue length reduction, than the corresponding increase for right turning vehicles. As volumes increase the right turn lane length becomes critical and right turning vehicles block access to left and through lanes.

As has been observed at other intersections, the testing has highlighted that Paramics may underestimate the capacity of the Matipo Street right turns by not reflecting the use drivers make of the amber and red time, particularly in congested periods.

As left turn and through movements are allocated their own lanes there is minimal effect on these movements except when right turn queues exceed the available storage.

The testing suggests that the practical implications of a rule change to near side priority at this intersection could include the need for longer right turn lanes or introduction of right turn signal phases.

5.8 Intersection 8: Matipo Street/Riccarton Road

5.8.1 Journey Times Method 1

Table 5-28 summarises the average journey time for all movements for each volume scenario.

Table 5-28 - Intersection 8, M1, Average Journey Time Comparison

Approach	Mvt	Average Journey Time (s/veh) for Various % Scenarios									
		75%		100%		125%		150%		175%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Riccarton Road (East)	L	61	53	61	54	62	55	63	58	87	83
	T	70	70	71	71	73	73	75	75	99	100
Matipo Street (South)	L	40	40	42	42	46	46	52	53	65	68
	R	55	55	57	57	57	57	59	59	60	62
Riccarton Road (West)	T	96	96	97	97	98	98	98	98	145	157
	R	105	107	110	112	115	117	123	125	246	264
Total	All	76	76	78	78	80	80	83	83	127	133

It is evident from the analysis that with the changed rule, as expected, that the right turn journey increases and the left turn journey time decreases. The decrease in left turn journey time is greater than the increase in right turn journey time for the 75% to 150% scenarios. Overall there is little difference in the total intersection performance until the 175% scenario when the existing rule proves more efficient.

Table 5-29 presents a summary of the increase or decrease in journey time for these two movements as a result of the rule change to near side priority.

Table 5-29 – Intersection 8, M1, Right and Left Turn Average Journey Time Changes

Movement	Change in Average Journey Time (s/veh) for Various % Scenarios				
	75%	100%	125%	150%	175%
Riccarton Road Right Turn	2	2	2	2	18
Riccarton Road Left Turn	-8	-7	-6	-5	-4

Table 5-29 highlights that the increase in right turn journey time as a result of the rule change to near side priority is smaller than the decrease in left turn journey time for the first four volume scenarios. For the last scenario the increase in right turn journey time is greater than the corresponding decrease for the left turn.

5.8.2 Queue Lengths Method 1

Table 5-30 summarises the average queue lengths for all movements for each volume scenario.

Table 5-30 - Intersection 8, M1, Average Queue Comparison

Approach	Mvt	Average Queue Length (vehicles) for Various % Scenarios									
		75%		100%		125%		150%		175%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Riccarton Road (East)	L	1.3	1.3	1.5	1.4	1.5	1.5	1.7	1.7	2.0	1.9
	T	2.4	2.4	3.0	3.0	3.9	3.9	4.7	4.7	9.2	9.3
Matipo Street (South)	L	1.6	1.6	1.8	1.8	2.0	2.0	2.5	2.5	3.7	4.0
	R	1.3	1.3	1.3	1.3	1.5	1.5	1.8	1.8	2.0	2.0
Riccarton Road (West)	T	1.6	1.6	1.9	1.9	2.2	2.2	2.4	2.4	2.6	2.6
	R	1.7	1.9	2.3	2.5	3.1	3.3	4.6	4.9	15.8	16.3

It is evident from the analysis that there is a very small increase in the right turn queue length on Riccarton Road and an even smaller decrease in the left turn queue. Overall there is very little difference between the modelled queue lengths on any approach under the two rules.

5.8.3 Discussion

The analysis has shown that the intersection of Matipo Street/Riccarton Road which is a three-arm signalised intersection with separate left and right turn lanes and a dedicated right turn phases would be affected only slightly by a rule change to near side priority.

Because there is a high demand on the right turn from Riccarton Road into Matipo Street there is a dedicated right turn phase provided and therefore only a proportion of right turning vehicles move through the intersection using priority rules. Therefore although some effects of the rule change to near side priority can be seen in the form of increased right turn lengths and journey times and corresponding reductions for the left turn, these effects are not dramatic.

The analysis suggests that possible implications of a rule change to near side priority at this intersection would be minimal. The main impact could be the demand for more time on the right turn phase if right turning vehicles find making that manoeuvre more difficult.

5.9 Intersection 9: Colombo Street/Peterborough Street

5.9.1 Journey Times Method 1

Table 5-31 summarises the average journey times for all movements for each volume scenario.

Table 5-31 - Intersection 9, M1, Average Journey Time Comparison

Approach	Mvt	Average Journey Time (s/veh) for Various % Scenarios									
		75%		100%		125%		150%		175%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Colombo Street (North)	L	25	25	25	25	25	25	26	25	26	25
	T	10	10	10	10	10	10	10	10	10	10
	R	19	20	21	20	21	22	22	24	22	24
Peterborough Street (East)	L	22	22	23	23	23	24	24	24	25	26
	T	29	30	31	31	32	33	33	35	35	37
	R	24	24	24	25	26	26	27	27	29	30
Colombo Street (South)	L	17	17	17	17	17	17	17	17	18	17
	T	8	8	8	8	8	8	8	8	8	8
	R	26	26	27	27	27	27	27	27	27	27
Peterborough Street (West)	L	17	17	18	18	19	19	20	20	22	22
	T	31	30	31	31	32	33	34	35	36	37
	R	18	18	19	19	20	20	22	22	23	23
Total	All	14	14	14	14	15	15	15	15	15	16

Table 5-32 presents a summary of the increase or decrease in journey time for these two movements as a result of the rule change to near side priority.

Table 5-32 – Intersection 9, M1, Right and Left Turn Average Journey Time Changes

Movement	Change in Average Journey Time (s/veh) for Various % Scenarios				
	75%	100%	125%	150%	175%
Colombo Street (North) R	0.4	-0.3	1.1	1.5	1.9
Colombo Street (South) L	-0.3	-0.4	-0.6	-0.5	-0.8
Colombo Street (South) R	0.2	0.1	0.3	0.4	0.4
Colombo Street (North) L	-0.3	-0.5	-0.4	-0.5	-0.5

Table 5-32 illustrates that in the first two scenarios there is very little difference between the existing and changed rule for either the right or left turn journey time. At 100% the right turn journey time actually shows a small decrease under the changed rule. Logically right turn journey time should increase however this result is most likely due to the very small differences and the variation that occurs between runs of a stochastic model. In the last three scenarios the right turn journey times increase by up to 2 s/veh and left turn journey times decrease by up to 1 second.

Overall there is very little difference between the two rules in terms of the overall journey time through the intersection.

5.9.2 Queue Lengths Method 1

Table 5-33 table summarises the average queue lengths for all movements for each volume scenario.

Table 5-33 - Intersection 9, M1, Average Queue Comparison

Approach	Mvt	Average Queue Length (vehicles) for Various % Scenarios									
		75%		100%		125%		150%		175%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Colombo Street (North)	L	1.0	0.0	1.0	1.0	1.0	0.0	1.0	0.0	1.0	1.0
	TR	1.0	1.0	1.0	1.1	1.0	1.0	1.1	1.1	1.1	1.1
Peterborough Street (East)	LTR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1
Colombo Street (South)	L	1.0	0.0	1.0	0.0	1.0	1.5	1.0	0.0	1.0	1.0
	TR	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1
Peterborough Street (West)	LTR	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.2	1.2

The table shows that there is very little difference between the two rules and this is mostly due to the fact there is very little queuing at this intersection under the tested volume scenarios.

5.9.3 Discussion

The results at this intersection have not shown any significant impacts of a rule change to near side priority. The main conclusion that can be drawn from this analysis is that the impacts of a rule change to near side priority at intersections with low traffic volumes are minimal.

In light of this a further test was undertaken that increased the traffic volume on the major road, Colombo Street by 500% and left the Peterborough Street volume the same as surveyed. Figure 5-49 shows the 15th-percentile, mean and 85-th percentile journey times for all movements through the intersection for the existing and changed rules. Each movement at the intersection is described on the graph axis by approach (North, East, South, and West) and movement (Left, Through and Right). The average journey time data is also summarised in

Table 5-34.

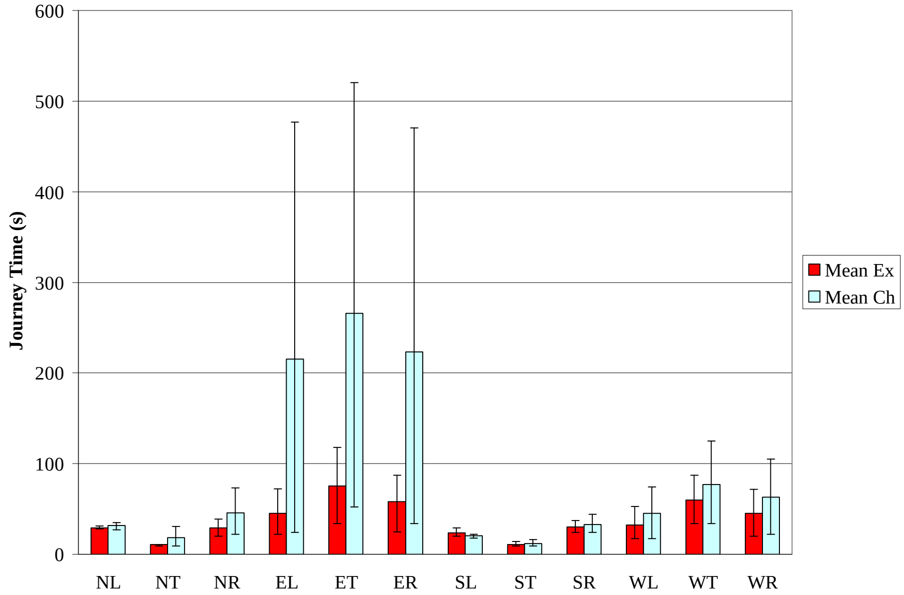


Figure 5-49 - Intersection 9, Extra Scenario Journey Time Analysis by Movement

Table 5-34 - Intersection 9, Extra Scenario Average Journey Times

Approach	Mvt	Volume (vph)	Average Journey Time (s)	
			Ex	Ch
Colombo Street (North)	L	36	29	32
	T	484	11	18
	R	76	29	46
Peterborough Street (East)	L	51	45	215
	T	22	75	266
	R	21	58	223
Colombo Street (South)	L	224	24	21
	T	988	11	12
	R	60	30	33
Peterborough Street (West)	L	9	33	45
	T	24	60	77
	R	16	45	63
Total	All	2443	17	25

The analysis shows that on Colombo Street, which is the major road featuring shared through and right lanes, both approaches experience higher journey times under the changed rule, with the exception of the left turn from Colombo Street south which reduces by 3 s/veh. Although it seems logical for the left turn journey time to reduce, at this intersection the major road has a short left turn lane and a shared through and right lane and queuing in the latter can prevent any vehicles being able to enter the former. With the right turn off the major road becoming more difficult following a rule change to near side priority, the frequency of such blocking increases.

The journey times from both Peterborough Street approaches increase substantially. This is an impact caused by the right turning vehicles finding it increasingly difficult to turn off the major road. Whilst vehicles are queued in the shared through and right lanes on the major road vehicles wishing to turn right or travel straight through from either Peterborough Street approach are forced to wait. As both Peterborough Street approaches consist of a shared lane for left, through and right turning vehicles, left turning vehicles are often caught in the queue also.

Figure 5-50 shows the modelled queue lengths for all lanes at the intersection and illustrates the increased queue length modelled on all approaches, particularly on the Colombo Street (North) approach and Peterborough Street (East) approach.

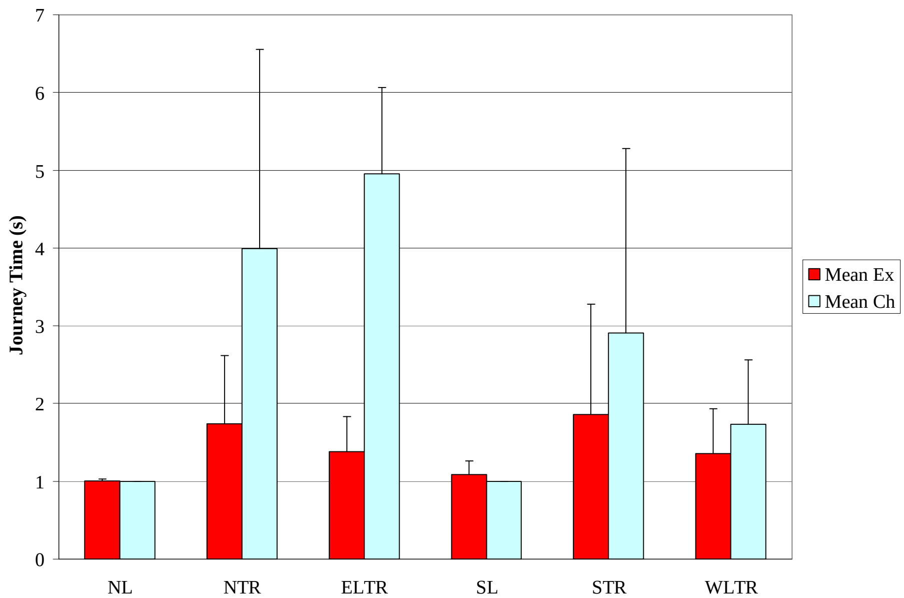


Figure 5-50 - Intersection 9, Extra Scenario Journey Time Analysis by Movement

Overall the analysis of this additional scenario highlights that intersections with shared through and right lanes would be particularly affected by a rule change to near side priority. There would be impacts in terms of increased journey times and queue lengths on the major road but there would also be impacts on the minor road as a consequence of the greater difficulty experienced by right turning vehicles on the major road.

5.10 Intersection 10: Halswell Junction Road/Main South Road

5.10.1 Journey Times Method 1

Table 5-35 summarises the average journey times for all movements for each volume scenario.

Table 5-35 - Intersection 10, M1, Average Journey Time Comparison

Approach	Mvt	Average Journey Time (s/veh) for Various % Scenarios									
		75%		100%		125%		150%		175%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Halswell Junction Rd (North)	L	114	123	282	273	461	459	515	423	291	315
	T	157	167	359	340	563	554	580	489	297	326
	R	164	173	375	354	547	560	609	541	287	321
Main South Road (East)	L	84	80	85	80	86	80	86	80	114	105
	T	81	81	81	81	81	81	81	81	109	105
	R	88	88	91	91	96	97	118	115	199	186
Halswell Junction Rd (South)	L	99	82	232	273	357	347	412	381	328	379
	T	154	150	370	401	545	555	654	582	532	547
	R	170	154	373	399	559	551	641	584	514	532
Main South Road (West)	L	33	28	34	28	35	28	36	29	43	37
	T	29	29	29	29	30	29	30	30	36	39
	R	36	37	38	39	42	44	51	68	96	111
Total	All	74	73	121	122	155	153	153	148	145	148

Table 5-36 presents a summary of the increase or decrease in journey time the right and left turn movements off Main South Road as a result of the rule change to near side priority.

Table 5-36 – Intersection 10, M1, Right and Left Turn Average Journey Time Changes

Movement	Change in Average Journey Time (s/veh) for Various % Scenarios				
	75%	100%	125%	150%	175%
Main South Road (East) R	0.3	0.3	0.8	-3.1	-13.5
Main South Road (West) L	-4.9	-5.7	-6.7	-6.9	-5.5
Main South Road (West) R	0.5	0.9	1.6	16.5	14.5
Main South Road (East) L	-4.5	-5.4	-5.8	-5.6	-9.2

Table 5-36 illustrates that generally the increase in right turn journey time is greater than the decrease in left turn journey time. Overall the intersection operates slightly more efficiently under the existing rule. The very high journey times on the northern and southern approaches to this intersection reflect that it is operating in a severely congested manner, therefore the overall average journey times for all movements through the intersection is of limited use in this case.

In the 175% scenario the average journey time for the right turn from the Main South Road (East) approach is better under the changed rule than the existing rule. This is counter intuitive as the right turn becomes opposed by more traffic and should become more difficult under a rule change to near side priority. The reason for the improvement in this case is due to the fact that the right turn lane on the opposite approach overflows at various stages, due to the greater difficulty of the right turn and blocks the eastbound through movement. With that movement blocked, the right turning vehicles from the east approach can move through unopposed. This situation is illustrated in Figure 5-51.

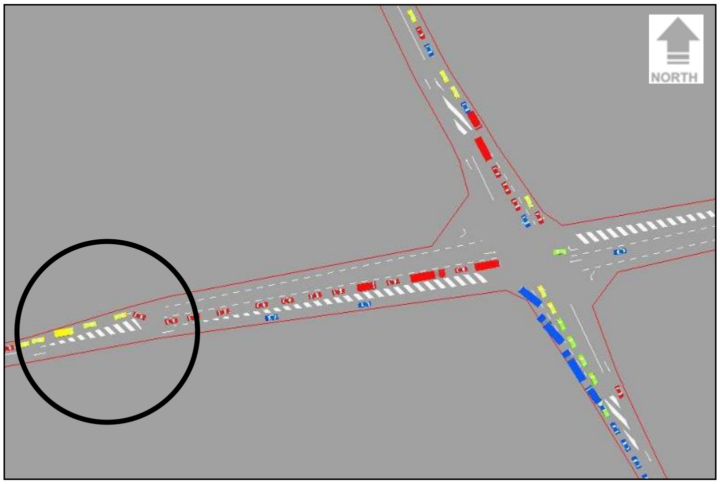


Figure 5-51 – Right Turn Lane Obstructing Through Movement (Intersection 10, M1, 175, Ch)

Figure 5-51 shows that the red vehicles on the west approach have filled the available right turn storage and are blocking the yellow vehicles, travelling straight through from behind them, from getting through the intersection. Consequently the green vehicle turning right from the east approach can move through unopposed.

5.10.2 Queue Lengths Method 1

Table 5-37 summarises the average queue lengths for all movements for each volume scenario.

Table 5-37 - Intersection 10 M1 Average Queue Comparison

Approach	Mvt	Average Queue Length (vehicles) for Various % Scenarios									
		75%		100%		125%		150%		175%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Halswell Junction Road (North)	L	4.9	4.1	17.2	20.3	41.2	41.9	47.3	47.5	48.4	49.4
	TR	2.1	2.1	3.9	4.0	5.3	5.5	5.6	5.8	5.8	5.5
Main South Road (East)	L	1.0	0.0	1.1	0.0	1.1	1.0	1.1	0.0	1.1	1.0
	T	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0
	R	1.0	1.0	1.1	1.1	1.2	1.2	1.8	1.7	3.4	3.0
Halswell Junction Road (South)	L	2.5	1.7	8.7	11.3	20.8	20.7	26.5	27.3	31.1	35.1
	TR	1.8	1.6	3.0	3.0	4.5	4.6	5.2	4.4	6.0	5.3
Main South Road (West)	L	1.0	0.0	1.0	1.0	1.1	0.0	1.1	1.0	1.1	1.0
	T	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1
	R	1.0	1.0	1.1	1.1	1.2	1.2	1.6	2.2	2.9	3.5

The analysis shows that on Main South Road (West) the average right turn queue length increases under the changed rule and the left turn queue length is virtually zero under the changed rule as expected. On Main South Road (East) the right turn queue length reduces for the same reasons described in the journey time section above.

The minor road approaches, Halswell Junction Road North and South are both heavily congested in both scenarios. The queue length analysis shows slightly shorted queues under the existing rule than the changed rule. This is most likely a reflection of the right turn lanes on Main South Road being occupied more consistently, reducing the opportunities for minor road vehicles to make their movement.

5.10.3 Discussion

The analysis has shown that at the intersection of Halswell Junction Road/Main South Road which is a four-arm stop controlled intersection with separate left and right turn lanes the greater difficulty experienced by vehicles turning right off Main South Road under the changed rule affects the whole intersection operation. The results require some interpretation however as the range of volumes tested are very high and model the intersection operating near capacity and well in excess of it. This intersection is scheduled for signalisation as part of the Transit 10 Year State Highway Forecast (Transit New Zealand, 2007) with construction scheduled for 2007/2008.

Were this intersection to remain in its present form, the analysis suggests that possible implications of a rule change to near side priority could include the need for a longer right turn lanes on Main South Road as a rule change to near side priority could put pressure on the available storage capacity and cause interference with the adjacent through lane, with certain traffic volume combinations.

Under the changed rule the minor road experienced a greater level of queuing and longer journey times. It is acknowledged that this intersection was modelled well beyond the realistic capacity of these approaches however the results provide some indication that a rule change to near side priority would make movements from the minor road more difficult. This could potentially bring forward the need for signalisation at this intersection or cause traffic to change their choice of route to other accesses points onto Main South Road.

5.11 Intersection Analysis Summary

5.11.1 Observations from Analysis

Review of the analysis results for all the intersections shows the following overall observations:

- Under the changed rule at a three-arm give way intersection it becomes increasingly difficult to turn right off the major road.

- Queuing of right turners on the major road prevents minor road vehicles leaving the minor road and consequently the overall intersection performance suffers.

- There is generally always some improvement in journey times and queue lengths for left turn movements, which become unopposed following a rule change to near side priority. However, also in almost all cases the positive effect for these vehicles is not as large as the negative effects for right turning vehicles.

- The three-arm signalised intersections that were modelled were generally not affected significantly by the rule change. This may be due to the presence of right turn signal phases and also the high through volumes which mean direct interaction between left and right turning vehicles is infrequent.

- Some right turns are very critical and reliant on amber time. This was particularly true for Intersection 4 – Bealey Avenue/Colombo Street, Intersection 6 - Innes Road/Papanui Road and Intersection 7 - Blenheim Road/Matipo Street. Paramics does not appear to model this to the extent that it occurs on street. The changed rule highlights the already critical nature of many of these turns.

- The rule can become almost irrelevant on multi-lane roads with high through volumes where direct conflicts between left and right turning vehicles in the absence of through vehicles from behind the left turning vehicles occur infrequently.

The analysis suggests the following practical implications that a rule change would have on the analysed intersections:

- The need for longer right turn lanes at almost all intersection types as volumes increase

- The need for signalisation at some three-arm priority intersections

- The need for dedicated right turn phases at some intersections

- The need to change lane configuration to remove shared right and through lanes

6 Lane Use Testing

6.1 Background

The use of through lanes at intersections with traffic signals has a significant impact on the capacity and operation of the intersection according to research undertaken by Royce, Jurisich and Dunn in 2006. This research looked specifically at the impact of short through lanes on upstream and downstream approaches and concluded that the length of such lanes has a significant impact on their use and their use has a significant impact on the overall capacity of the intersection.

Through lane use was defined in the research as being the percentage of the total through traffic using that lane. The optimum situation is even lane use. The target lane uses are therefore 50% for two-lane roads, 33% for three-lane approaches and 25% for four-lane approaches.

Various factors can influence the use of through lanes at a signalised intersection. These include the presence of adjacent turning lanes and their use, kerbside parking and the length of the lane itself and any downstream short lane.

This thesis will use Paramics to investigate the effect of the presence of adjacent through lanes identified by Royce, Jurisich and Dunn (2006) and any other impacts that a change to the New Zealand left turn rule could have on through lane use and consequently overall intersection performance, at intersections with multiple through lanes.

Three of the ten intersections analysed in Section 5 (Intersection 4: Bealey Avenue/Colombo, Intersection 5: Main North Road/Prestons Road and Intersection 7: Blenheim Road/Matipo Street) have multiple through lanes. Aerial photographs of these intersections were presented in Figure 4-7, Figure 4-9 and Figure 4-13 respectively. Traffic signal plans showing their lane arrangements are presented in Appendices A5, A6 and A7 respectively). Intersection 5 is of particular interest as its Main North Road (North) approach includes a through lane and a shared through and left lane.

The following sections describe investigation into the use of through lanes at Intersection 5: Main North Road Prestons Road and Intersection 4: Bealey Avenue/Colombo Street. The purpose of these investigations is to identify potential impacts of a change to near side priority on multi-lane roads with and without shared through and turning lanes respectively. Some additional scenarios, with different hypothetical layouts have also been tested.

6.2 Main North Road/Prestons Road Lane Use Analysis

6.2.1 Impacts on Shared Lane Use

The layout of the intersection of the Main North Road/Prestons Road was shown previously as Figure 4-9. For each Method 1 scenario (75%, 100%, 125%, 150% and 175% of the total intersection volume) vehicle detection loops were placed in each lane in the model. At the end of the modelled 90-minutes the vehicle counts from each loop were recorded. Table 6-1 and

Table 6-2 present the results for the existing and changed rule respectively for the Main North Road (North) approach. It is noted that in all cases lanes are numbered from the kerbside lane inwards towards the centre of the road. In this case Lane 1 is the kerbside shared through and left lane (TL) and Lane 2 the through lane (T).

Table 6-1 – Main North Road/Prestons Road (North) Lane Use, Existing Rule (90 minutes)

Scenario	Lane 1 (TL) (vehicles)	Lane 2 (T) (vehicles)	Total (vehicles)	% Lane 1 (TL)	% Lane 2 (T)
M1 75%	582	419	1,001	58%	42%
M1 100%	714	619	1,333	54%	46%
M1 125%	867	802	1,668	52%	48%
M1 150%	972	1,029	2,001	49%	51%
M1 175%	1,086	1,246	2,332	47%	53%

Table 6-2 – Main North Road/Prestons Road (North) Lane Use, Changed Rule (90 minutes)

Scenario	Lane 1 (TL) (vehicles)	Lane 2 (T) (vehicles)	Total (vehicles)	% Lane 1 (TL)	% Lane 2 (T)
M1 75%	605	397	1,003	60%	40%
M1 100%	769	564	1,333	58%	42%
M1 125%	921	750	1,671	55%	45%
M1 150%	1,071	930	2,001	54%	46%
M1 175%	1,206	1,125	2,331	52%	48%

The results show that the modelled lane use is affected by which rule is applied. In all cases Lane 1, which is a shared through and left lane, is used by more vehicles under the changed rule than with the existing rule. This reflects how under the existing rule the left turning vehicles that use this lane can delay vehicles behind them when they are required to give way to an opposing right turning vehicle. This appears to reduce the attractiveness of Lane 1 for through vehicles.

Under the changed rule the left turn movement is unopposed and the disruption caused by left turning vehicles to through vehicles following in the same lane is limited only to the deceleration required in order for them to make their left turn.

Observation of the model suggests that in a real-life situation a rule change to near side priority would result in greater certainty or reliability in using a shared through and left lane. Under the existing rule, particularly on busy multi-lane roads such as Main North Road, it is common for left turning vehicles to be shielded by through vehicles in the adjacent lane. When this occurs the opposing right turning vehicle has to give way to the oncoming through vehicle and the left turning vehicle can move through the intersection unopposed. Table 6-1 shows that under the existing rule the relative use of Lane 1 decreases as the total intersection volume increases. This suggests there is some equilibrium or optimum point where the overall delay to all vehicles is minimised.

What a rule change to near side priority offers is increased certainty for drivers that if they are using a shared through and left lane the worst that they will encounter is the delay due to the vehicle in front of them slowing in order to make their left turn. Under the existing rule there is a chance that the left turning vehicle in front could have to come to a complete stop to give way to opposing right turning vehicles.

Overall the testing has shown that Paramics does model a difference in lane use under each rule and this difference is greater use of the shared through and left lane under the changed rule.

The use of the two through lanes on the Main North Road (South) approach was also recorded. This approach features two through lanes and a separate right turn lane. Table 6-3 and Table 6-4 present the lane use results for the existing and changed rules respectively.

Table 6-3 – Main North Road/Prestons Road (South) Lane Use, Existing Rule (90 minutes)

Scenario	Lane 1 (T) (vehicles)	Lane 2 (T) (vehicles)	Total (vehicles)	% Lane 1 (T)	% Lane 2 (T)
M1 75%	796	400	1,195	67%	33%
M1 100%	995	598	1,593	62%	38%
M1 125%	1,206	788	1,994	61%	39%
M1 150%	1,381	1,013	2,395	58%	42%
M1 175%	1,609	1,186	2,795	58%	42%

Table 6-4 – Main North Road/Prestons Road (South) Lane Use, Changed Rule (90 minutes)

Scenario	Lane 1 (T) (vehicles)	Lane 2 (T) (vehicles)	Total (vehicles)	% Lane 1 (T)	% Lane 2 (T)
M1 75%	796	400	1,196	67%	33%
M1 100%	1,018	576	1,594	64%	36%
M1 125%	1,196	796	1,992	60%	40%
M1 150%	1,379	1,014	2,393	58%	42%
M1 175%	1,636	1,168	2,803	58%	42%

Table 6-3 and Table 6-4 show that there is very little difference in the number of vehicles using each lane on the Main North Road (South) approach as a result of the rule change to near side priority. Therefore although the right turn movement does become more difficult under a rule change to near side priority there isn't an impact on the use of the adjacent lanes. Were the separate right turn lane to overflow on a regular basis there could be some effect on the use of the adjacent through lane.

6.2.2 Intersection Performance

A further scenario was tested to assess the link between lane use and the overall intersection performance. For this test the traffic volumes in the Main North Road/Prestons Road intersection model were increased to the point where the model was operating in a very congested but stable and realistic manner. The test was run with the existing and changed rule and the use of each lane was recorded as well as the journey times for each movement.

Table 6-5 – Main North Road/Prestons Road Lane Use

	Main North Road (North)				Main North Road (South)			
	Lane 1 (TL)		Lane 2 (T)		Lane 1 (T)		Lane 2 (T)	
Existing	837	43%	1,121	57%	1,595	70%	685	30%
Changed	971	52%	1,056	48%	1,609	70%	698	30%

Table 6-6 – Main North Road/Prestons Road Journey Times

Approach and Movement		Volume (vph)	Average Journey Time (s/veh)					
			Movement		Approach		Intersection	
			Ex	Ch	Ex	Ch	Ex	Ch
Main North Rd (South)	T	2,216	100	99	107	106	111	99
	R	289	161	159				
Prestons Rd (East)	L	200	63	63	73	72		
	R	236	81	80				
Main North Rd (North)	T	1,654	120	96	125	97		
	L	261	153	107				

Table 6-5 shows that the use of the two south approach through lanes is again unaffected by which rule is applied. On the north approach the changed rule results in more use of Lane 1 and more even use of the two lanes.

The journey time results presented in Table 6-6 show that the changed rule results in better intersection performance. On the North approach in particular the average journey time for the through movement reduces by 24 s/veh and the journey time for the left turn movement reduces by 46 s/veh. On the South approach there are small improvements and as expected, the East approach is not significantly affected. The improvements for the North approach produce an overall improvement for the intersection, reducing the overall average journey time through the intersection by 12 s/veh.

As this analysis was undertaken using the same set of fixed-time signal phases and times it is possible that the analysis has underestimated the improvements. With the more even use of the two approach lanes from the North this approach may require less green time and more time could be allocated to other movements to achieve better overall performance.

Overall the results of this additional test suggest that a rule change to near side priority could result in improved performance at intersections such as Main North Road/Prestons Road which have multilane approaches including shared left and through lanes. A rule change to near side priority could effectively increase the lifespan of these intersections and delay the need for upgrades. In particular the need for auxiliary left turn lanes could be delayed or removed altogether. Through lanes would be used in a more even manner and as described in the research by Royce, Dunn and Jurisich (2006) this can increase the capacity of the intersection and make more efficient use of existing infrastructure as well as reducing the likelihood of vehicle re-routing or 'rat running' through other areas to avoid such intersections.

6.3 Bealey Avenue/Colombo Street Lane Use Analysis

6.3.1 Intersection Performance

The layout of the Bealey Avenue/Colombo Street intersection was shown previously in Figure 4-7. Using the same methodology as described in Section 6.2.2 above, the traffic volumes in the Bealey Avenue/Colombo Street intersection model were increased to the point where the model was operating in a very congested but stable and realistic manner. The test was run with the existing and changed rule and the use of each lane was recorded as well as the journey times for each movement.

Table 6-7 – Bealey Avenue/Colombo Street Lane Use (90 minutes)

	Bealey Avenue (West)						**Bealey Avenue (East)**					
	Lane 2 (T)		**Lane 3 (T)**		**Lane 4 (T)**		**Lane 2 (T)**		**Lane 3 (T)**		**Lane 4 (T)**	
	vph	%	vph	%	vph	%	vph	%	vph	%	vph	%
Existing	1,086	36%	1,051	35%	859	29%	1,077	41%	991	37%	589	22%
Changed	1,081	36%	1,062	35%	851	29%	1,084	41%	1,009	38%	566	21%

Table 6-8 – Bealey Avenue/Colombo Street Journey Times

Approach and Movement		Volume (vph)	Average Journey Time (s/veh)					
			Movement		Approach		Intersection	
			Ex	Ch	Ex	Ch	Ex	Ch
Colombo Street (North)	L	45	81	81	84	85	142	143
	T	112	85	85				
	R	35	86	89				
Bealey Avenue (East)	L	77	145	144	147	149		
	T	2,511	143	145				
	R	83	255	284				
Colombo Street (South)	L	125	57	56	58	57		
	T	102	57	56				
	R	49	60	60				
Bealey Avenue (West)	L	109	148	147	149	149		
	T	2,854	147	147				
	R	95	205	210				

Table 6-7 shows that the use of the three through lanes on Bealey Avenue is only very slightly affected by the rule change. As there are both separate left and right turning lanes on both Bealey Avenue approaches, under free flowing operation the through lanes are not expected to be affected by the adjacent turning lanes. If right turns off Bealey Avenue were to become more difficult as a result of a rule change to near side priority then the through lane immediately adjacent could be affected by a queue extending beyond the capacity of the right turn lane. This would make the lane less attractive to through traffic, due to the increased probability of getting stuck among the right turn queue unnecessarily.

Overall the analysis supports the intuitive conclusion that where the are separate right turning lanes at an intersection, the use of adjacent through lanes and the associated impacts on intersection performance are not expected to be significant following a change to near side priority. However this could change in heavily congested conditions where the length of the right turning lane is not sufficient to accommodate the right turn queue, which the analysis of Section 5.4.2 suggests could increase following such a change.

In terms of the overall intersection performance Table 6-8 shows only very small changes are expected to most movements and a difference of 1 second overall. The largest changes are to the right turns off Bealey Avenue with the average journey time increasing by 29 s/veh from the East approach and 5 s/veh from the West approach.

It is interesting to note that there is very little change for the Colombo Street approaches which feature shared through and right lanes. It is expected that under the changed rule there would be some effect on both the right turning vehicles and the through vehicles sharing the lane. This is not evident however and the most likely cause is the low right turning volumes, which are 35 vph from the north and 40 vph from the south, in combination with low through volumes which are 112 vph from the north and 102 vph from the south.

6.4 Hypothetical Shared Through and Right Lane Use Analysis

6.4.1 Intersection Layout

A hypothetical arrangement based on the Main North Road/Prestons Road intersection model was developed to test impacts on a shared through and right lane. This intersection layout which features one through lane with a shared through and right lane on the South approach is shown as Figure 6-1.

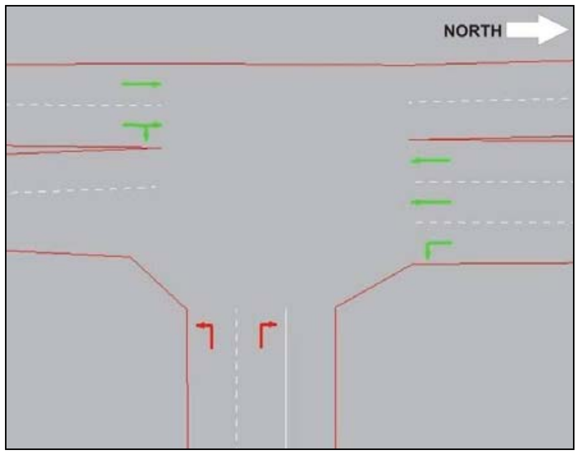


Figure 6-1 – Hypothetical Shared Through and Right Intersection

The North approach has been changed to include a separate left turning lane, in order to isolate the impacts of the shared through and right lane on the south approach. The East approach remains unchanged.

6.4.2 Intersection Performance

Using the same methodology as described in Section 6.2.2 above, the traffic volumes in the intersection model were increased to the point where the model was operating in a very congested but stable and realistic manner. The tested volumes are shown in Table 6-10. The test was run with the existing and changed rule and the use of each lane was recorded as well as the journey times for each movement. Table 6-9 presents a summary of the lane use for each rule.

Table 6-9 - Hypothetical Shared Through and Right Lane Use

<table>
<tr><th></th><th colspan="4">South</th><th colspan="4">North</th></tr>
<tr><th></th><th colspan="2">Lane 1 (T)</th><th colspan="2">Lane 2 (TR)</th><th colspan="2">Lane 1 (T)</th><th colspan="2">Lane 2 (T)</th></tr>
<tr><td>Existing</td><td>681</td><td>49%</td><td>697</td><td>51%</td><td>1,338</td><td>73%</td><td>495</td><td>27%</td></tr>
<tr><td>Changed</td><td>699</td><td>51%</td><td>682</td><td>49%</td><td>1,363</td><td>74%</td><td>468</td><td>26%</td></tr>
</table>

Table 6-9 shows that on the south approach the use of the shared through and right lane decreases slightly under the changed rule as right turning becomes more difficult. Table 6-10 presents the average delay for each movement under each rule.

Table 6-10 - Hypothetical Shared Through and Right Journey Times

<table>
<tr><th colspan="2" rowspan="3">Approach and Movement</th><th rowspan="3">Volume (vph)</th><th colspan="6">Average Journey Time (s/veh)</th></tr>
<tr><th colspan="2">Movement</th><th colspan="2">Approach</th><th colspan="2">Intersection</th></tr>
<tr><th>Ex</th><th>Ch</th><th>Ex</th><th>Ch</th><th>Ex</th><th>Ch</th></tr>
<tr><td rowspan="2">South</td><td>T</td><td>1,565</td><td>64</td><td>67</td><td rowspan="2">71</td><td rowspan="2">77</td><td rowspan="6">67</td><td rowspan="6">70</td></tr>
<tr><td>R</td><td>233</td><td>123</td><td>141</td></tr>
<tr><td rowspan="2">East</td><td>L</td><td>155</td><td>61</td><td>61</td><td rowspan="2">71</td><td rowspan="2">71</td></tr>
<tr><td>R</td><td>180</td><td>80</td><td>80</td></tr>
<tr><td rowspan="2">North</td><td>T</td><td>1,362</td><td>61</td><td>61</td><td rowspan="2">62</td><td rowspan="2">61</td></tr>
<tr><td>L</td><td>217</td><td>65</td><td>62</td></tr>
</table>

Table 6-10 shows that under the changed rule the right turn journey time from Main North Road (South) increases by 18 s/veh and the average journey time for the through movement from his approach also increases by 3 s/veh. The overall intersection average journey time increases by 3 s/veh. This analysis supports the logical conclusion that at intersections that have approaches with shared through and right lanes these approaches will experience increased journey time.

The individual intersection analysis results presented in Section 5 showed that a change to near side priority could bring forward the need for dedicated right turn phases and longer right turn lanes. This further analysis highlights the obvious conclusion that shared through and right lanes will be particularly affected. It was shown in Section 6.2 that intersections with shared through and left lanes could improve following a change to near side priority through both improved functioning of the shared lane and a more even distribution of traffic across lanes. This analysis indicates that shared through and right lanes will experience the opposite effect and will experience worse performance in the shared lane and potentially under use of that lane for the through movement. Consequently longer journey times through the intersection will result as that lane becomes less attractive and through lane use becomes more uneven.

6.5 Hypothetical Shared Through and Right and Shared Through and Left Lane Use Analysis

6.5.1 Intersection Layout

A hypothetical arrangement was developed to test impacts on approaches which have two lanes, one shared through and left and one shared through and right. The side road approaches (East and West) are modelled as one lane. This intersection arrangement is shown as Figure 6-2.

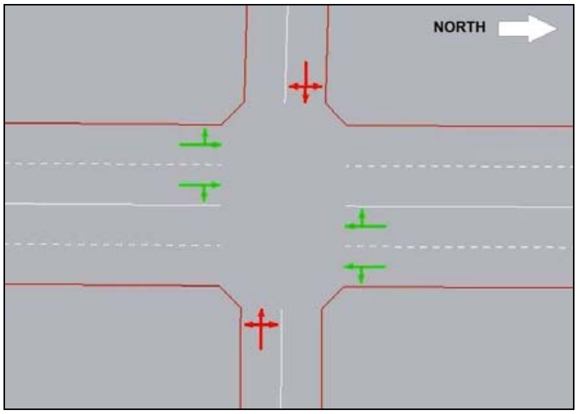


Figure 6-2 – Hypothetical Shared Through and Right and Shared Through and Left Intersection

6.5.2 Intersection Performance

Using the same methodology as described in Section 6.2.2 above, the traffic volumes in the intersection model were increased to the point where the model was operating in a very congested but stable and realistic manner. The tested volumes were symmetric with both major road approaches having volumes of 125 vph turning left, 1,100 vph travelling through and 125 vph turning right. The minor road approaches, which are not focussed on in this testing were given volumes of 200 vph travelling through. A two phase signal arrangement was adopted with a cycle time of 80 seconds of which 65 seconds was given to the major road. The test was run with the existing and changed rule and the use of each lane was recorded as well as the journey times for each movement. Table 6-11 presents a summary of the lane use for each rule.

Table 6-11 - Hypothetical Shared Through and Right and Through and Left Lane Use

	North Approach				South Approach			
	Lane 1 (TL)		Lane 2 (TR)		Lane 1 (TL)		Lane 2 (TR)	
Existing	819	61%	531	39%	805	60%	544	40%
Changed	1,030	78%	291	22%	1,106	79%	276	21%

Table 6-11 shows that on the North approach the changed rule results in a shift of traffic to Lane 1, the kerbside lane. This is due to the right turn becoming more difficult and more through vehicles avoiding this lane. This also happens on the south approach where the use of each lane changes from 60% using Lane 1 under the existing rule to 79% using Lane 1 under the changed rule. Table 6-12 presents the average delay for each major road movement and approach under each rule.

Table 6-12 - Hypothetical Shared Through and Right and Shared Through and Left Journey Times

Approach and Movement		**Volume (vph)**	**Average Journey Time (s/veh)**			
			Movement		**Approach**	
			Ex	**Ch**	**Ex**	**Ch**
North	L	123	60	121	80	176
	T	1,076	83	169		
	R	124	73	301		
South	L	123	53	82	82	139
	T	1,078	85	130		
	R	122	88	276		

Table 6-12 shows that under the changed rule the right turn journey times from both the North and South approach increase from 73 s/veh to 301 s/veh on the North approach and from 88 s/veh to 276 s/veh on the South approach. This has implications for the left and through movements from each approach. Lane 2, which is used by the right turning vehicles, becomes decreasingly attractive for through vehicles and consequently they use Lane 1 more and the overall performance of the intersection suffers as a result.

Despite becoming an unopposed movement, the left turns from both approaches also experience increases in journey times due to the interaction with more through vehicles using the shared through and left lane. This analysis suggests that the increase in journey time experienced by right turning vehicles following a rule change is not matched by a corresponding decrease for left turning vehicles and this type of intersection. This leads to the conclusion that intersections with shared through and right lanes are likely to be affected by a change to near side priority and that the change will affect not only right turning vehicles but the overall performance of the intersection.

7 Impacts on a Network

The analysis presented so far in this thesis has considered single intersections operating in isolation. The number of vehicles making each movement is fixed. In real road networks drivers have a choice of which route to take to get to their desired destination. If, as was observed in some of analysis contained in Section 5 of this thesis, some movements and intersections experience severe congestion, drivers can chose to avoid that movement or intersection. Some testing has therefore been undertaken using a Paramics model of a large road network with dynamic assignment to assess the impact of a rule change in a model where drivers have the ability to change routes and avoid movements and intersections with high journey times. Dynamic assignment is described further in Section 7.1.

7.1 The Christchurch Central Business District Paramics Model

The Christchurch Central Business District Paramics Model (Christchurch CBD Model) was commissioned by Christchurch City Council (CCC) and has been calibrated to 2005 traffic volumes and conditions. It is a grid network shaped approximately square and some 2 km long on each side. A screen shot of the model is shown in Figure 7-1.

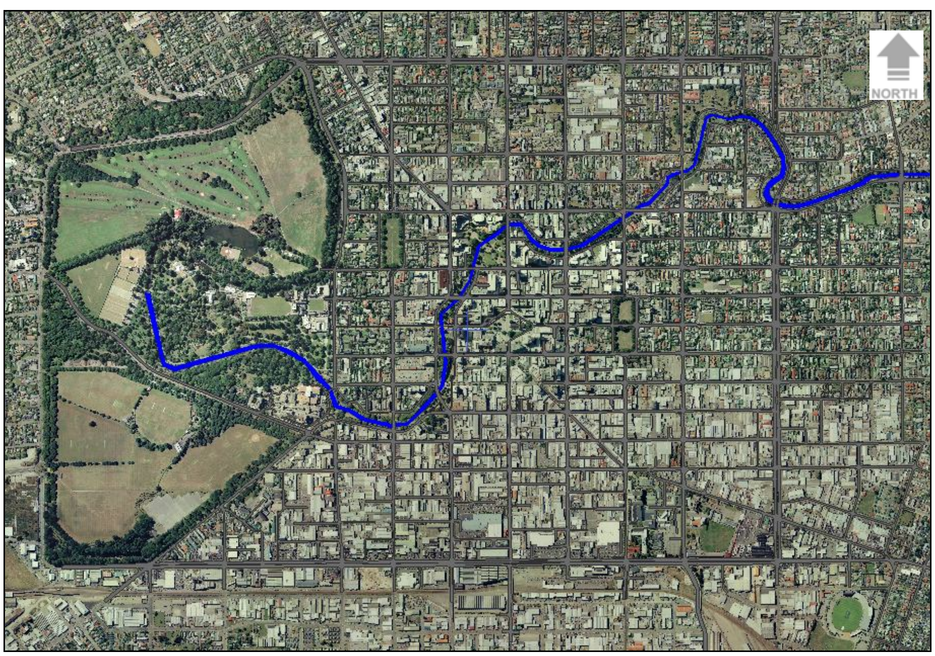


Figure 7-1 – Christchurch CBD Paramics Model

The model has been calibrated to morning ("AM"), inter-peak ("IP") and evening ("PM") time periods with both fixed-time and adaptive signal control. The AM encompasses 7:00am to 9:30am, the IP

1:00pm to 3:30pm and the PM 4:00pm to 6:30pm. The two most critical periods with the highest traffic volumes, the AM and PM models have been analysed in this section.

The model operates with stochastic dynamic assignment which means that the model uses the generalised cost equation, perturbation and dynamic feedback to determine which route each vehicle will use to get from their origin to their destination.

Each vehicle calculates the cost of a route using the generalised cost equation which is a combination of time, distance and any tolls or charges that may apply. Time, distance and tolls are each given a weighting specified by the user. In the Christchurch CBD model the generalised cost equation is weighted 80% on time and 20% on distance and no tolls apply.

Perturbation is used in Paramics to add a degree of variance or a stochastic element to the calculation of cost to reflect that not all drivers perceive or calculate cost and distance in exactly the same way. A percentage algorithm of perturbation (5%) is used in the Christchurch CBD model. This means that each vehicle calculates the true cost of a route then takes a random perturbation value of up to plus or minus 5% of the true value.

Dynamic assignment allows vehicles in the network to reselect its choice of route at a specified time interval. In the Christchurch CBD model this interval is four minutes. Information about the delay experienced by all vehicles already in the network is fed back to vehicles and used to adjust their perceived cost of each route. This information is only fed back to vehicles classified as familiar. In the Christchurch CBD model 60% of light vehicles are classified as familiar and 40% as unfamiliar. Familiar drivers will use dynamic assignment information and use both major and minor routes. Unfamiliar drivers will not use dynamic feedback and will stick to major or signposted routes whenever possible. All the heavy vehicles in the model are all classified as familiar. How much delay information is fed back to vehicles is controlled by the feedback factor. This acts as a smoothing or filtering factor. In the Christchurch CBD model this factor is 0.7.

All these factors and parameters were tested and determined during the development of the Christchurch CBD model by the consultants acting for Christchurch City Council, Baseplus Limited, and have not been changed in this testing.

7.2 Methodology

The testing that has been undertaken involves reviewing all intersections in the Christchurch CBD model and identifying those that would be affected by a rule change to near side priority, as modelled by Paramics. In Section 2.9.2 it was discussed how Paramics does not model the New Zealand left turn rule as it applies to the minor approaches of four-arm priority intersections. These movements do not have their priority changed in Paramics and are for the purpose of the analysis in this section referred to as ‘unaffected’. A discussion of the limitations of Paramics in regard to this is presented in Section 2.9.2.

Not all left turn movements have direct conflict with right turning vehicles and vice versa. For example some left turn movements within signalised intersections operate on Give-Way control (as described in Section 2.9.2), some turns have dedicated signal phases which mean they never had to give way to other turn vehicles, some movements are barred and the one-way streets that operated within the Christchurch CBD mean that many turning conflicts are completely removed. In all these cases and any others where right and left turning movements are not affected by a rule change, these movements are referred to as ‘not affected’.

All affected movements had their priority changed to what would happen following a rule change to near side priority and the AM and PM models were each run ten times with statistics collected and averaged across all ten runs for:

- Turning movements
- Link counts
- Overall network journey time, distance and speed
- Intersection movement travel time

These statistics were all compared to the AM and PM models as they currently existing with the New Zealand left turn rule (far side priority) in place.

Turning movements, link counts and intersection delay statistics have been reported for a one-hour period 7:30am to 8:30am in the AM model and 4:30-5:30pm in the PM model. Overall network statistics cover the full modelled period of two and a half hours.

7.3 Results

7.3.1 Overall Network Statistics

Overall network statistics for average travel time, total distance travelled, the total number of vehicles in the network and the modelled mean speed are presented in Table 7-1. These statistics cover the full modelled period for both models, 7:00am to 9:30am for the AM and 4:00pm to 6:30pm for the PM.

Table 7-1 – Overall Network Statistics Comparison

Period	Rule	Average Journey Time (s)	Total Distance (km)	Total Number Vehicles (veh)	Average Speed (km/h)
AM (7:00am-9:30am)	Existing	322	105,061	59,814	19.7
	Changed	308	105,112	59,797	20.6
	Difference	-14	+50	-16	0.9
	%	-4%	0%	0%	5%
PM (4:00pm-6:30pm)	Existing	257	120,861	77,650	21.8
	Changed	274	120,876	77,650	20.5
	Difference	+16	+15	0	-1.3
	%	+6%	0%	0%	-6%

Table 7-1 shows that during the AM period there is a decrease of 14 s/veh (4%) in the average journey time through the network. There is a corresponding increase of 5% in the average speed through the network. During the PM period the changed rule results in an increase of 16 s/veh (6%) in the average journey time through the network and a reduction of 6% in the average speed.

7.3.2 Traffic Flows

Figure 7-2 shows a link count difference plot for the modelled AM network under the existing and changed rules for the period 7:30am to 8:30am. The difference is calculated from the link flow with the changed rule minus the link flow with the existing rule. The lighter coloured yellow bar represents an increase in link flow following a rule change to near side priority to near side priority. The darker coloured red bar represents a decrease in link flow following a rule change from far side priority to near side priority. The width of the bars is proportional to the size of the increase or decrease in vph. Each link is separated by direction therefore the flows are all one-directional.

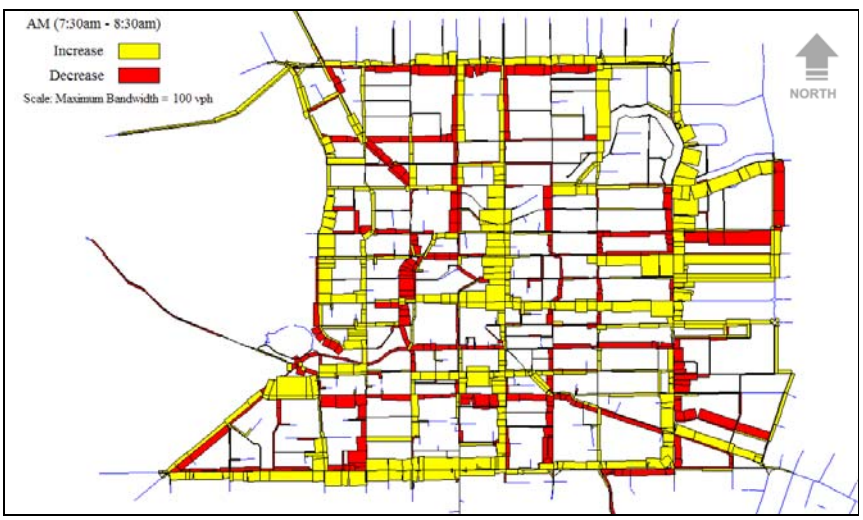


Figure 7-2 – AM Link Count Differences

The largest increase in any average link volume is 85 vph and the largest decrease is 50 vph. These results suggest that a rule change to near side priority to near side priority could have an effect on route choice through a network.

Review of the link counts from each of the ten individual runs of the model used to produce the average for each rule shows that there is also a high degree of variation between model runs for the same rule. The full results are presented in Appendix A13.

The difference between the average link counts for the two rules has been compared to the range of results obtained for the ten runs. There are 1,861 links that make up the model network. For only nine of these links the average difference was greater than the range of results for the ten model runs. For all the remaining links the variation between the highest and lowest modelled link flows was larger than the average difference between the existing and changed rules. Therefore it is not conclusive from the AM model whether a rule change to near side priority to near side priority could affect route choice. It is possible that it does, however this is masked by the stochastic nature of Paramics and the variable route choice that occurs in each and every run of a grid network such as the Christchurch CBD.

Figure 7-3 shows a link count difference plot for the modelled PM network under the existing and changed rules. The difference is calculated from the link flow with the changed rule minus the link flow with the existing rule. The lighter coloured yellow bar represents an increase in link flow following a rule change to near side priority to near side priority. The darker coloured red bar represents a decrease in link flow following a rule change to near side priority to near side priority The width of the bars is proportional to the size of the increase or decrease in vph. Each link is separated by direction therefore the flows are all one-directional.

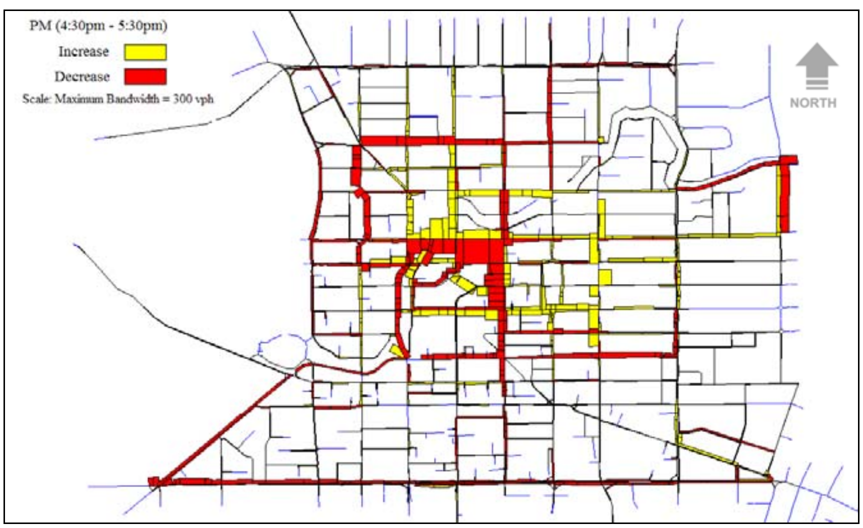


Figure 7-3 – PM Link Count Differences

The largest increase in any average link volume is 161 vph and the largest decrease is 223 vph. These results again suggest that a rule change from far side priority to near side priority could have an effect on route choice through a network.

As for the AM model, review of the link counts from each of the ten individual runs of the model used to produce the average for each rule shows that there is also a high degree of variation between model runs for the same rule. The full results are presented in Appendix A14.

For 20 of the 1,861 links making up the network the average difference was greater than the range of results for the ten model runs. For all the remaining links the variation between the highest and lowest modelled link flows was larger than the average difference.

7.3.3 Number of Left and Right Turns Made

Table 7-2 presents the AM and PM model results for the number of affected and not affected left and right turns made.

Table 7-2 – Number of Left and Right Turns Comparison

Period	Rule	Affected by Rule Change		Unaffected by Rule Change	
		Left Turns	Right Turns	Left Turns	Right Turns
AM (7:00am-9:30am)	Existing	17,283	16,464	17,646	18,598
	Changed	17,885	16,481	17,669	18,622
	Difference	602	16	23	24
	%	3%	0%	0%	0%
PM (4:00pm-6:30pm)	Existing	18,304	18,920	22,142	21,633
	Changed	18,446	18,683	22,037	21,641
	Difference	142	-237	-105	7
	%	1%	-1%	0%	0%

In the AM model the number of affected left turns made increases by 302 vph or 3%. There is very little change in the number of right turns made, an increase of 16 which equates to less than 1%. The changes in both the left and right unaffected turns are small, showing increases of 23 vph and 24 vph respectively.

In the PM model there is also an increase in the number of affected left turns made. This increase is 142 vph or approximately 1%. There is a decrease in the number of affected right turns made of 237 vph or approximately 1%. The results for the unaffected turns shown that there is a decrease in left turns of 105 vph and very little change in the number of right turns.

Overall these results suggest that there is some likelihood that a change to the road rule governing left and right turning vehicles turning into the same road would change the performance of some critical left and right turns and reduce the attractiveness of some right turns and increase the attractiveness of some left turns.

It is noted that the dynamic routeing in Paramics is link-based not turn-based therefore delay information from individual turns does not feed back to vehicles. Instead, this turning delay becomes part of the link delay information that is fed back to vehicles. This is likely to introduce some damping into the information but will still reflect the higher or lower delay that is experienced by all vehicles on each link.

The results for the unaffected turns are generally small which supports that the differences observed for the affected turns is in fact due to the changes in priority. The difference of 105 vph for the unaffected left turns in the PM model does however show that there is some degree of random variation inherent in all simulations and this could explain some of the variation.

7.3.4 Intersection Performance

The journey times for each movement at each major intersection in the model was recorded and used to give an overall average journey time through each intersection. This was recorded for the existing and changed rule and the difference calculated.

Figure 7-4 shows the difference in s/veh for the AM model. As the difference is calculated from the changed rule minus the existing rule, a negative number represents an improvement.

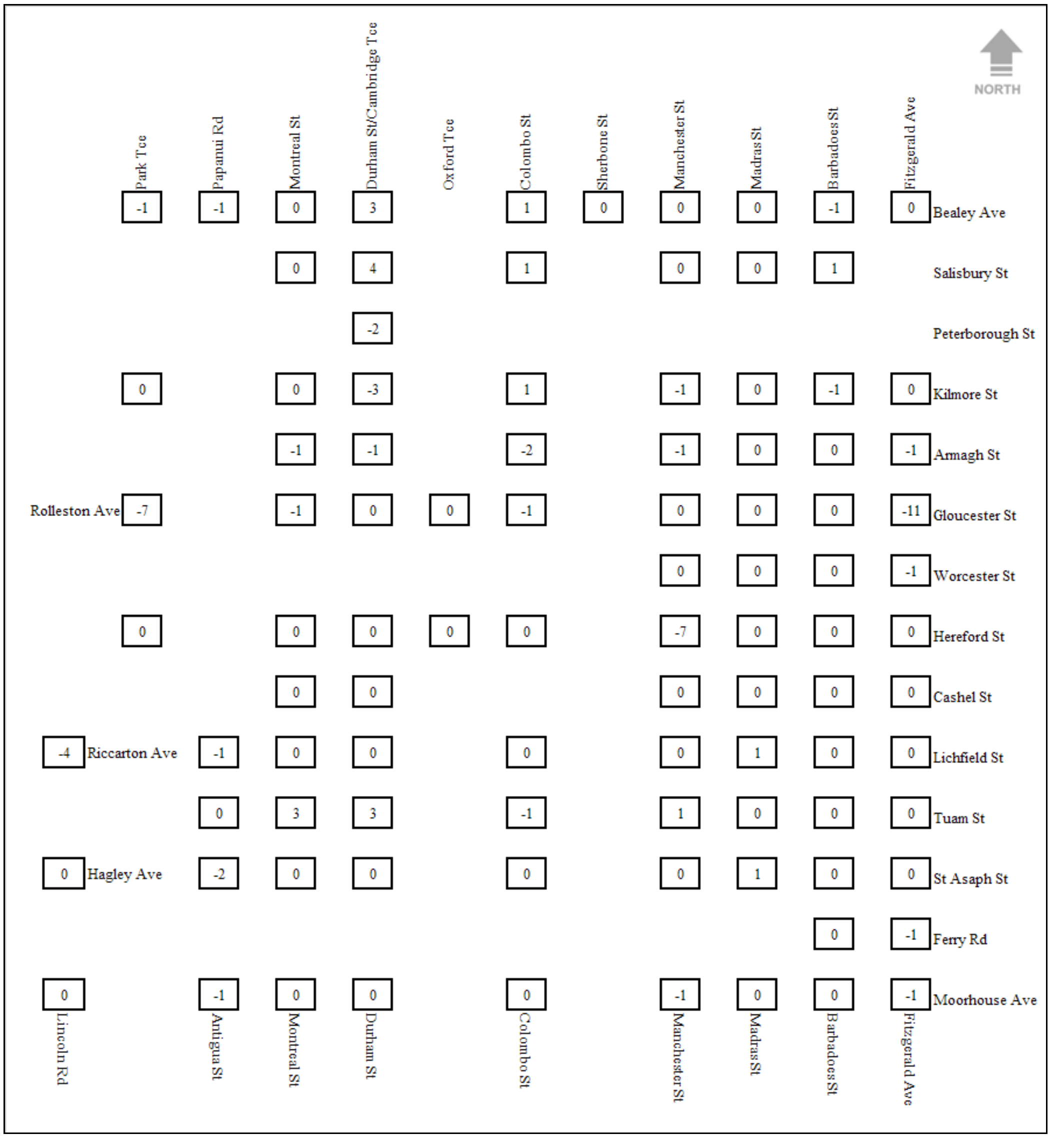


Figure 7-4 – AM Intersection Performance Differences (s/veh)

Figure 7-4 shows that the differences are generally small with the maximum increase in travel time being 4 s/veh and the maximum decrease being 11 s/veh.

Figure 7-5 presents the changes on a histogram showing the number of intersections that have experienced the changes which range from -11 s/veh to 4 s/veh.

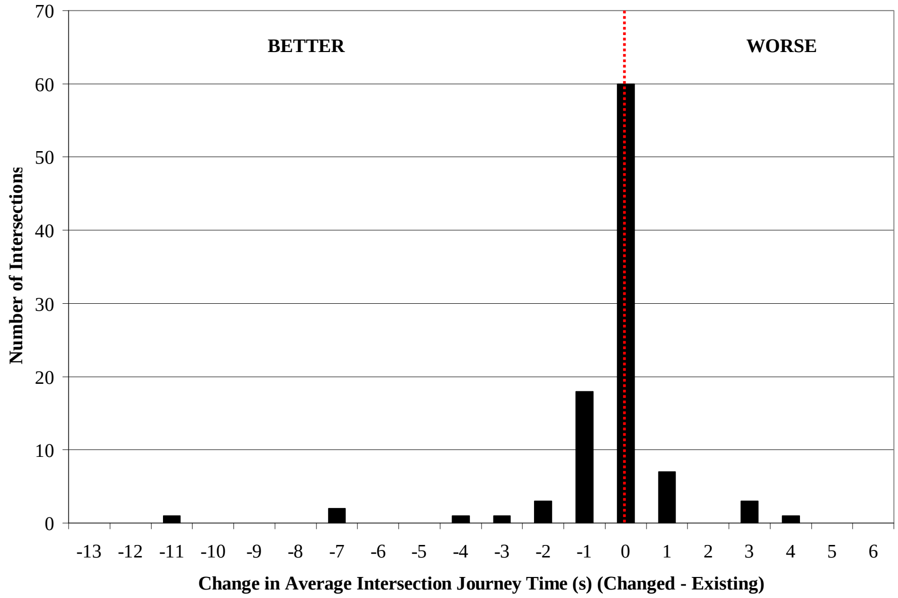


Figure 7-5 – AM Intersection Performance Histogram

Figure 7-5 shows that most intersections are not affected or affected only within the range of -1 s/veh to 1 s/veh. The spread of changes shows that there are more intersections improving under the changed rule and that where there is an improvement it is generally larger than the worsening at any intersection.

Figure 7-6 summarises the changes as either better ("B" and shown in yellow), worse ("W" and shown in red) or no change ("N/C" and shown in light blue).

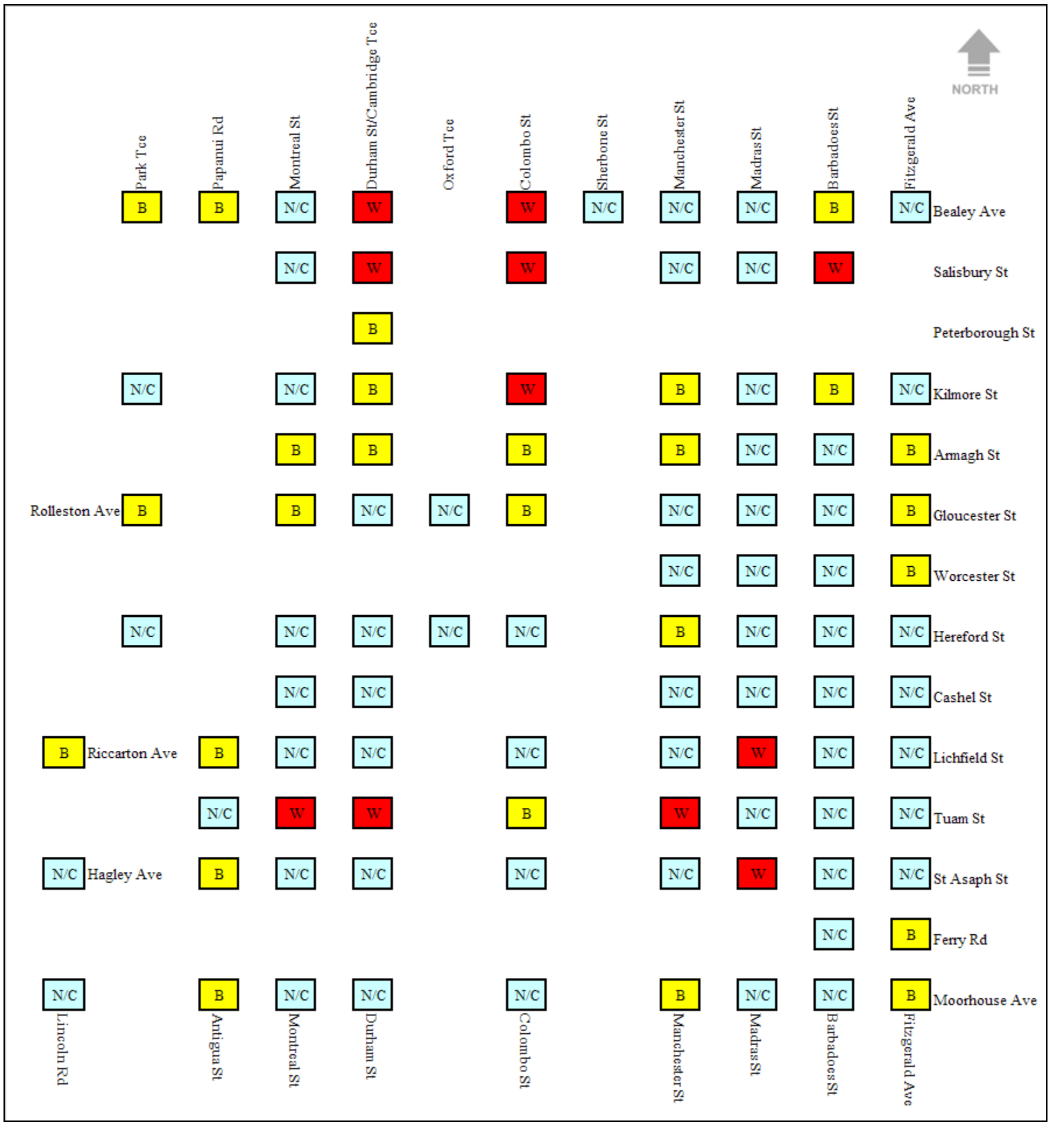


Figure 7-6 – AM Intersection Performance Difference Summary

Of the 97 intersections included in the analysis 26 (27%) performed better following the rule change to near side priority to near side priority, 11 (11%) performed worse and 60 (62%) were unchanged.

Figure 7-7 presents the changes on a histogram showing the number of intersections that have experienced the changes which range from -13 s/veh to 6 s/veh.

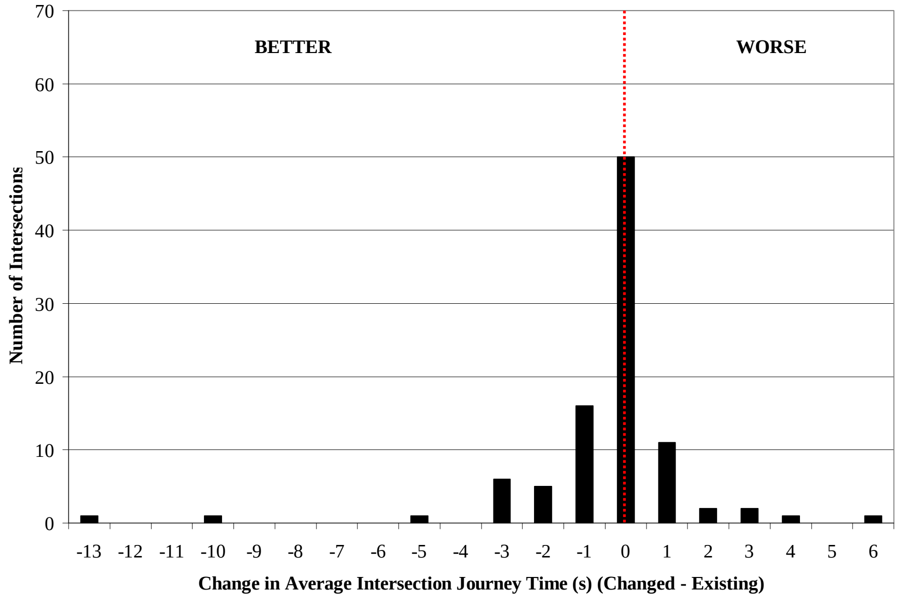


Figure 7-7 – PM Intersection Performance Histogram

Figure 7-7 shows that most intersections are not affected or affected only within the range of -3 s/veh to 3 s/veh. The spread of changes shows that there are more intersections improving under the changed rule and that where there is an improvement it is generally larger than the worsening at any intersection.

Figure 7-8 shows the difference in s/veh for the PM model. Once again a negative number represents an improvement.

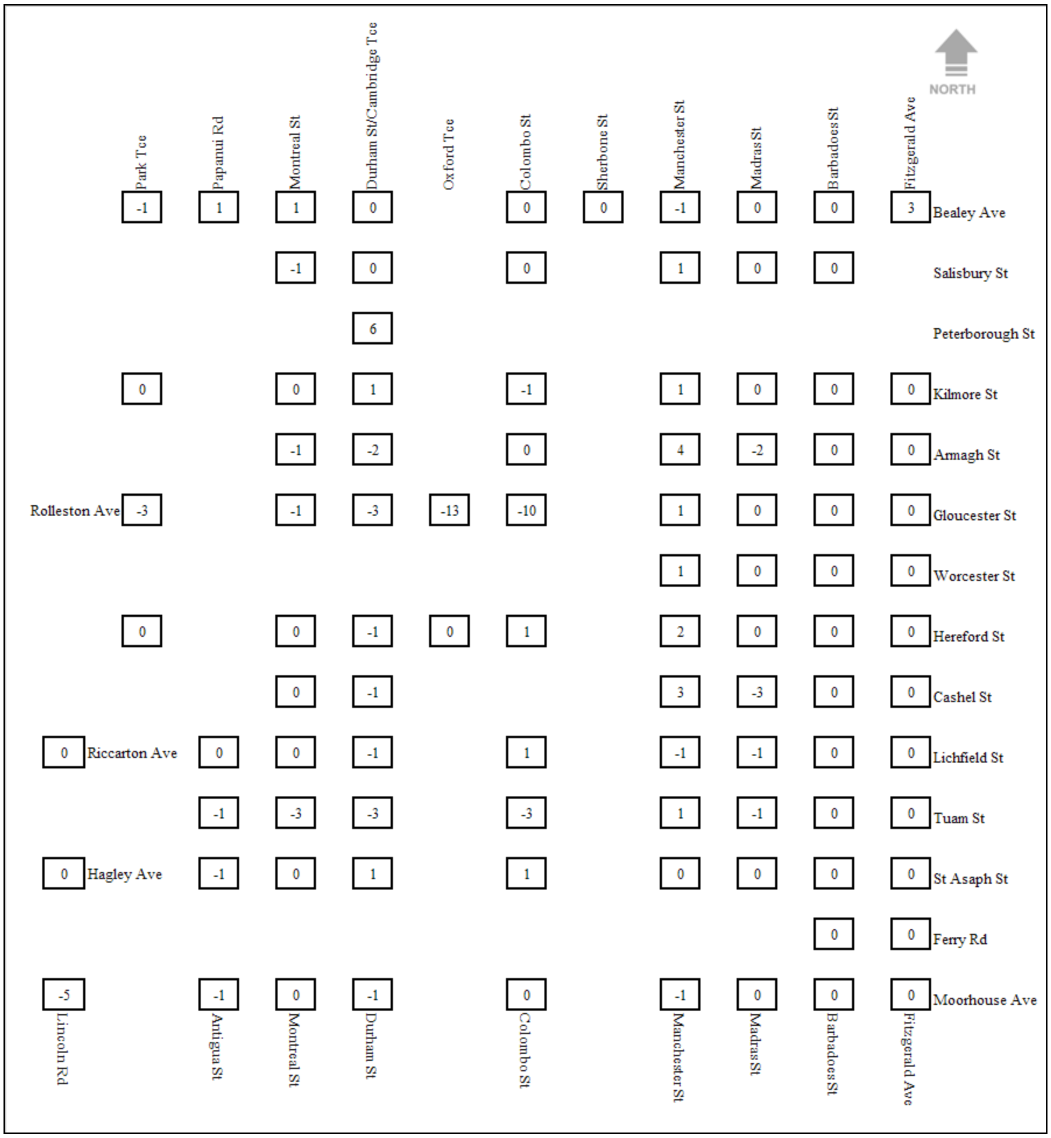


Figure 7-8 – PM Intersection Performance Differences (s/veh)

Figure 7-8 shows that the differences are generally small with the maximum increase in travel time being 6 s/veh and the maximum decrease being 13 s/veh. Figure 7-9 summarises the changes as either better ("B" and shown in yellow), worse ("W" and shown in red) or no change ("N/C" and shown in light blue).

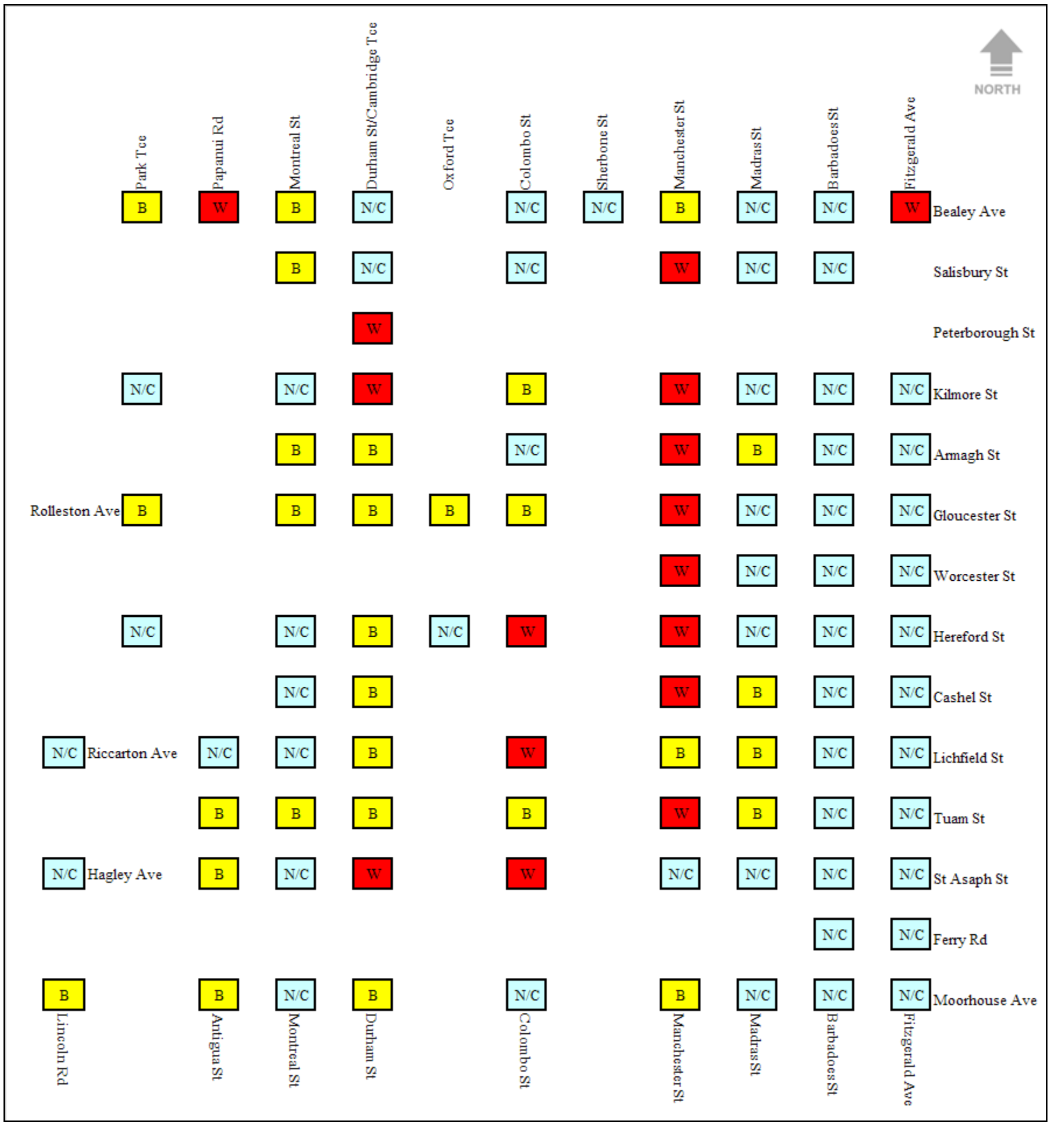


Figure 7-9 – PM Intersection Performance Difference Summary

Of the 97 intersections included in the analysis 29 (30%) performed better following the rule change to near side priority to near side priority, 16 (16%) performed worse and 52 (54%) were unchanged.

Figure 7-9 highlights that along Colombo Street and Manchester Street there several intersections which are worsened by the changed rule. The types of intersections that are common on these streets are discussed in Section 8.2.3.

8 Discussion

8.1 Questions Raised in the Literature Review

In Section 2.10 the literature review concluded with a series of issues or statements that have now been investigated by this thesis. A discussion of each of these issues is presented below.

Does the current rule reduce or minimise right turn delays?

Yes in some cases it does. The research suggests that the affected intersections fall in a middle range of intersection types of volumes. At low volumes intersections are typically unmarked or give-way or stop-controlled. At these intersections the low volumes mean that the likelihood of right and left turning vehicles interacting with each other is low and journey time implications for either vehicle are similarly low. This would change as volumes increased, particularly in the situation where the lanes are narrow and operated with shared through and right or shared through and left configuration. However, as volumes increase the intersections get upgraded and dedicated turning lanes are provided.

This research has shown that at three-arm and four-arm give-way or stop controlled intersections that have varying lane configurations, the rule does have an impact and it does presently give right turning vehicles turning off the major road more opportunity to make their turn. When the rule was changed these vehicles queued on the major road for longer waiting for a suitable gap and this had implications for queue length in the right turn lane, the interaction of the overflowing right turn lane with the adjacent through lane and also for vehicles wanting to turn out of the major road. These vehicles could not make their turn while vehicles were waiting to turn right off the major road and consequently the minor road approach suffered queuing and journey time implications also. This is consistent with the findings of Daltrey (1980) which identified that far side priority reduces delay for minor road vehicles.

These impacts were generally seen at higher volume scenarios and in reality, when such volumes begin to occur the intersection would be upgraded and possibly become signalised. At signalised intersections both three-arm and four-arm the impacts of the rule were less dramatic. This is due to a number of factors including the presence of dedicated signal phases for right turns, the presence of left turns operating on give-way control and also the high opposing through volumes. When opposing through volumes are high the occurrence of a left and right turning vehicle meeting each other in the absence of through vehicles becomes very infrequent and the rule becomes irrelevant.

At signalised intersections that had no right turn phases, the current rule does improve right journey times. There are also impacts on the journey times of movements other than right turns where they are indirectly affected. The main example is a single shared through and left lanes where a left turning vehicle having to stop to give way to a right turning vehicle causes delay to through vehicles behind them.

Overall the rule has little impact on right turn journey times at low volumes, some impact at mid-range volume intersections and lesser impact as the standard of intersection and the volumes through it increase.

If the rule is changed will right turn delays increase?
Yes, as described above.

Will any change be matched by a decrease in delay for left turn movements?
No the decrease experienced by left turning vehicles is generally much less than the increase for right turning vehicles.

Is there any difference in the overall performance of each rule?
There are differences but it is not possible from this research to say whether one rule is better than the other. At some intersections near side priority offers better intersection performance and at others far side priority offers better performance. Which rule is better depends on the number of vehicles making each movement through the intersection and the layout, lane configuration, form of control and signal phasing of the intersection.

Will vehicles use the left lane multi-lane roads more if the rule is changed?
This research suggests that the rule does decrease the attractiveness of shared through and left lanes. When the left turn becomes unopposed the lane is used more and the overall distribution of traffic across all lanes on the approach is more even and therefore the intersection operates more efficiently and may have a longer useful lifespan.

The research also shows that shared through and right lanes become less attractive after a rule change and more through traffic is attracted to adjacent lanes, given less even distribution and worse overall intersection performance.

Does the rule change to near side priority have different impacts on different intersection types and different volumes?
Yes.

Are intersections less likely to block under the changed rule?
This research has shown that blocking occurs with the changed rule when right turn queue length exceeds the available queue length in the right turn lane. It is also feasible that under the existing rule

a left turn lane, particularly a short left turn lane or a shared through and left lane could also become blocked. It isn't possible to conclude from this research whether all intersections are more or less likely to block under either rule. This once again depends on the intersection layout, lane configuration, volumes and form of control.

In a network situation will vehicles re-route and, for example avoid difficult right turns such that the overall effect on the network is negligible?

The testing on the Christchurch CBD Paramics model suggests that the rule change would have an impact on route choice and that vehicles would redistribute to minimise the delay they experience. Overall there was very little difference in the network statistics for each model run which suggests that the network-wide impacts of a rule change in terms of journey time and efficiency would be very small.

Are there any design considerations arising from the rule change to near side priority? For example, will some priority intersections required signalisation earlier as a result of a rule change to near side priority? Will some right turn bays need to be introduced or extended? Will right turn phases be required?

Yes. Longer right turn lanes could be required, right turn phases could be required and some give way and stop controlled intersections could require signalisation earlier under the changed rule than they would have under the existing rule.

8.2 What Types of Intersections are Affected?

The intersections analysed in this thesis and some other examples from around Christchurch have been grouped together into four general groups. These are:

- Group 1 – Unaffected Intersections
- Group 2 – Affected Give Way and Stop Controlled Intersections
- Group 3 – Affected Traffic Signal Intersections
- Group 4 – Unaffected Traffic Signal Intersections

Each group and their common characteristics are described below.

8.2.1 Group 1 – Unaffected Intersections

These sorts of intersections have low traffic volumes and commonly occur on the local road network serving residential areas. Their approaches are mostly marked as single lane, or not marked at all and they are either uncontrolled, or controlled by give way or stop signs. Some examples are shown in Figure 8-1.

Gresford Street/Trist Place | Champion Street/Gresford Street

Dorset Street/Park Terrace | Manchester Street/Peterborough Street

Figure 8-1 – Group 1 Unaffected Intersections

Whether near or far side priority is in place is not expected to affect these intersections because traffic volumes through intersection are low and therefore the interaction between right and left turning vehicles is infrequent. If traffic volumes were to increase to a level that intersection performance became an issue it is likely that the intersection form would be upgraded to include turning lanes or a different form of control. The other obvious inclusions in unaffected intersection types are grade-separated intersections and roundabouts where near side or far side priority rules are not relevant.

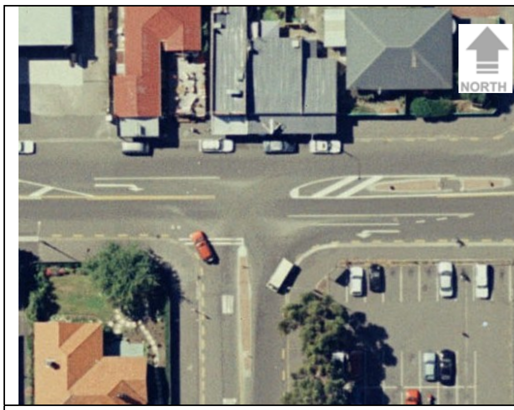
The intersections of Gresford Street/Trist Place and Champion Street/Gresford Street are presented as examples of low volume single lane intersections located in residential areas.

The intersection of Dorset Street/Park Terrace and Manchester Street/Peterborough Street are located on more major roads in the central Christchurch area however the minor roads, Dorset Street and Peterborough Street respectively have low volumes. The form of these intersections, in particular their lack of dedicated turning lanes, indicates that neither the turning volumes into or out of the minor road justifies the provision of turning lanes and therefore the interaction between left and right turning vehicles would also be infrequent.

None of these types of intersections are expected to be significantly affected by a rule change and therefore none were investigated as part of this thesis.

8.2.2 Group 2 – Affected Give-Way and Stop Controlled Intersections

These sorts of intersections have higher traffic volumes than those in Group 1 and commonly occur on either busier local roads or collector and arterial roads. Their approaches commonly feature dedicated turning lanes and they are controlled by either give way or stop signs. Some examples are shown in Figure 8-2 including Intersections 1, 9 and 10 which were investigated in this thesis.



Intersection 1 – Barbadoes Street/Warrington Street

Intersection 9 – Colombo Street/Peterborough Street

Intersection 10 – Halswell Junction Road/Main South Road

Hills Road/North Avon Road

Figure 8-2 – Group 2 Affected Give Way and Stop Controlled Intersections

A change to the road rules is expected to affect these types of intersections. They are higher standard intersections than those in Group 1 and carry higher traffic volumes and in particular higher turning volumes. Although it is acknowledged that Paramics does not fully represent the operation of minor approaches at four-arm priority intersections (as described in Section 2.9.2), the analysis in this thesis highlighted issues at both three and four-arm intersections of this nature on the major road and consequential impacts for the minor road(s).

At these intersections far side priority creates more opportunity for right turning vehicles to turn off the major road. A change to near side priority makes this more difficult and consequently effects such as longer right turn queues on the major road are expected and it becomes for difficult for minor road vehicles, who need the major road right turners to clear the intersection before they can go, experience greater difficultly also.

At such intersections the need for installation of traffic signals could brought forward particularly at intersections were the current intersection is operating at or near capacity and where turning volumes are higher.

8.2.3 Group 3 – Affected Traffic Signal Intersections

These sorts of intersections are at the lower end of the traffic signalised intersection spectrum. They are signalised intersections that feature some of the following elements:

- Shared through and left or shared through and right lanes
- Short turning lanes
- Right turns that do not have dedicated right turn phases

Six examples of these sorts of intersections are presented in Figure 8-3 below including Intersections 2, 4, 5 and 6 which were investigated in this thesis.

Intersection 2 – Breezes Road/Pages Road

Intersection 4 – Bealey Avenue/Colombo Street

Intersection 5 - Main North Road/Prestons Road

Intersection 6 – Innes Road/Papanui Road

Gloucester Street/Manchester Street

Barbadoes Street/Bealey Avenue

Figure 8-3 – Group 3 Affected Traffic Signal Intersections

At these intersections issues can arise from the greater difficulty right turning vehicles experience under near side priority. If lanes are shared there is greater delay experienced not only by right turning vehicles but also by the other vehicles in the shared lane. If there are short turning lanes, the available queuing capacity can be exceeded and vehicles can overflow into adjacent lanes. This can block intersection approaches.

The Gloucester Street/Manchester Street intersection is presented as an example of a type of intersection that was not included in this thesis but could experience similar impacts to others in this group. All approaches to this intersection have two lanes. The kerbside lane is unmarked and the adjacent lane marked as shared through and right. The kerbside lane can be used by vehicles travelling through and is typically used only when a right turning vehicle is waiting to turn in the shared through and right lane and blocking through movement. When there is no right turning vehicle present the through vehicles typically stay in the shared through and right lane and the kerbside lane is used by left turning vehicles.

Modelling this behaviour, which in reality depends on the combinations of vehicles present, is difficult. The movements that are permitted from each lane must be specified. Modelling the kerbside lane as through and left would overestimate the capacity of the intersection as it models it as operating with two through lanes all the time. Conversely, modelling the kerbside lane as left-only underestimates the capacity on some occasions. For this reason intersections with this configuration, which are common in Christchurch, were not selected for the analysis of this thesis. Instead intersections with clearly marked lane arrangements were chosen.

These types of intersections would be affected by a change to far side priority in the same manner as other intersections in this group. The greater difficulty experienced by right turners would reduce the use of the shared through and right lane reduce the overall capacity of the intersection similar to what was modelled on the Colombo Street approaches to the Bealey Avenue/Colombo Street intersection.

It is noted that in the network testing described in Section 7.3.4 many intersections along Manchester Street and Colombo Street were shown to perform worse following a change to near side priority. Intersections with layouts similar to that at Gloucester Street/Manchester Street are common on these roads.

The Main North Road/Prestons Road intersection highlights a situation where a change to far side priority would produce a benefit. The Main North Road (North) approach to this intersection features a shared through and left lane and with a change to near side priority the operation of this lane and the overall approach improves.

At some intersections, for example Bealey Avenue/Colombo Street, the layout of the approaches can be very different and these intersections could be part of either Group 3 or Group 4.

The other type of intersection that could be included in Group 3 is represented by the example of Barbadoes Street/Bealey Avenue. The reason this intersection has been included as potential affected is because of traffic volume patterns rather than specific layout issues, although some features may also contribute. Barbadoes Street is part of the inner city one-way system and during the morning peak period particularly the left and right turning volumes into Barbadoes Street from Bealey Avenue are high.

Observation of the operation of this intersection during this period shows that these movements are the dominant movements and at this time there can be little through traffic in one or both directions along Bealey Avenue. Therefore, there is a high degree of interaction between the left and right turning volumes into Barbadoes Street and the priority rules are very relevant. In cases such as this, the impacts of a rule change could be the requirement for more queue storage capacity for a right turn movement and the need for less for the left turn movement.

8.2.4 Group 4 – Unaffected Traffic Signal Intersections

As the standard of a traffic signalised intersection improves the potential impact of a rule change reduces. Intersections included in this group commonly have some or all of the following features:

- Dedicated right turn phases
- Give-way controlled left turn lanes
- Multiple through lanes
- Separate lanes for all movements
- Long turning lanes

Four examples of these sorts of intersections are presented in Figure 8-4 below including Intersections 3, 7 and 8 that were investigated in this thesis.

Intersection 3 – Marshland Road/The Palms

Intersection 7 - Blenheim Road/Matipo Street

Intersection 8 Matipo Street/Riccarton Road

Northcote Road/Queen Elizabeth 2 Drive/Main

	North Road

Figure 8-4 – Group 4 Unaffected Traffic Signal Intersections

At these intersections, which typically occur on the minor and major arterial network, the traffic volumes and turning volumes are sufficiently high to justify the intersection features described above.

Some of these features, such as right turn phases and give way controlled left turn lanes, remove the situation where left and right turning vehicles are required to consider whether near or far side priority is in place.

On multi-lane roads, which have multiple lanes because of their high traffic volumes, many right and left turns (if they are not on a dedicated turn phase or a give way) are performed with a high number of through vehicles in adjacent lanes and once again the situation of right and left turning vehicles having to consider each other occurs infrequently. This sort of effect was seen in the investigation of Intersection 4 - Bealey Avenue/Colombo Street. However, this intersection has been placed in Group 3 since the Colombo Street approach is affected by the rule and the Bealey Avenue approach is also due to its short right turn lanes.

At the intersections in this group the impacts of a change to near side priority are expected to be minimal.

8.3 What are the Effects for a Network?

A graphical representation has been developed to identify which combinations of intersections and traffic volumes are likely to be affected by a rule change. It is acknowledged that grouping intersections in any simple way is difficult as there are many different combinations of layouts, signal arrangements, and traffic patterns possible. There will always be exceptions and grey areas.

The graph presents intersection types on the vertical axis and uses traffic volume as the horizontal access. The horizontal access can also be considered to represent the increasing standard of the intersection since intersections with high traffic volumes are typically of a higher standard. Higher standard intersections include some or all of the features identified in the Group 4 intersections as described above in Section 8.2.4.

Figure 8-5 below illustrates which combinations of intersection type and traffic volume are expected to be affected by a change from far side to near side priority.

Figure 8-5 – Affected Intersection Type Summary

The horizontal access could also be considered as representing the status of the roads forming the intersection in the road hierarchy. The Christchurch City Plan includes a hierarchical network of roads that classifies each road according to the function it is intended to have in the network. The classifications are local road, collector road, minor arterial and major arterial. At the local road end of the hierarchy, roads are intended to provide for a high degree of property access. At the major arterial end, roads provide for a high degree of traffic movement and a lesser degree of access to adjacent land uses (Christchurch City Council, 2005). The horizontal axis of Figure 8-5 could be considered as having local roads at the left hand end through to major arterials at the right hand end.

8.4 Is the Effect Positive or Negative?

The findings of this research suggest that it is not possible to confidently state whether one rule is better than the other.

Typically the results show that the increase in journey time and queue length for right turning vehicles exceeds any corresponding decrease for left turning vehicles. There are some exceptions however such as at intersections that feature shared through and left lanes or short left turn lanes that are likely to exceed queuing capacity and impede adjacent through lanes. Similarly intersections with shared through and right lanes experience the opposite, negative effect.

In most cases the rule change accentuates an issue that is likely to become an issue as traffic volumes increased regardless of a rule change. For example right turns off Bealey Avenue at the Bealey Avenue/Colombo Street intersection are modelled as critical with the existing rule and become even more critical with the changed rule. Right turn phases or longer right turn lanes could be required at this intersection as a result of the rule, or they could be required anyway as a result of general traffic growth.

Similarly at give way and stop controlled intersection the need for signalisation could be brought forward based on the minor road journey times becoming unacceptably higher. This would be accentuated by a rule change but could also result from general traffic growth.

The opposite effect may result at intersections with shared through and left lanes or short left turn lanes where the infrastructure that is currently in place could have its useful life extended by a rule change.

The results of the Christchurch CBD Paramics model testing strongly suggest that the sorts of impacts that were seen in the isolated intersection analysis could be removed altogether by redistribution of traffic volumes or driver rerouting across a network. Where drivers have different routes available to them it is likely that if a particular right turn became difficult following a rule change, vehicles would redistribute to achieve an overall equilibrium again.

Therefore in grid networks such as the Christchurch CBD or other networks with lots of available route choice, the impact of a rule change could ne neutral.

On areas of the network where there is little route choice, such as major arterial corridors, the option to re-route isn’t available and the impacts could be more perceptible. An example in the Christchurch network is the intersection of Main North Road/Johns Road. This intersection is currently almost essential for vehicles travelling between the Waimakariri District and Christchurch City. Changing the rule could impact on the right turn performance however because this intersection has high traffic volumes, a high standard layout, right turn phases and is at the strategic end of the road hierarchy, it is unlikely to be affected anyway.

This research has highlighted an interesting overlap between safety and efficiency in intersection design and performance. Many of the intersection features identified as contributing to intersection being less affected by a rule change are identified as road safety countermeasures in the Austroads Guide to Treatment of Crash Locations (Austroads, 2004). These countermeasures include:

- Installing traffic signals
- Dedicated right turn phases
- Removing all filtering movements using a red arrow
- Banning right turns
- Providing or extending auxiliary right and left lanes
- Providing pedestrian crossings on left turn slip lanes

These are all measures that have been described in this thesis as features of intersections that reduce the impact of whether near side or far side priority is in place. Therefore if any of these measures were taken to improve efficiency they would also result in a safer intersection. Similarly if they were installed to address safety issues they would not only improve safety, but offer efficiency benefits and make the intersection less sensitive to the potential impacts of a rule change. The more common these features become on a road network, the more neutral the effect of a rule change.

The overall conclusion from this research is that the impacts of the rule change will be mixed. The difference in intersection performance is not expected to be dramatic or even highly perceptible. However intersections with the features mentioned above, and sufficiently high traffic volumes to make them critical, would require investigation prior to a rule change taking effect.

Although some impacts of a rule change, such as road safety benefits can be quantified and represented in financial terms, this research suggests that attempting to quantify changes to road user costs such as travel time and vehicle operating costs would be exceedingly difficult. This is because there are so many possible combinations of traffic volumes, intersection layouts and forms of control. Furthermore, this thesis has also only looked at times of the day when intersections are relatively busy. A full economic analysis would have to consider patterns of traffic movements over the course of a full day, week and even the year.

8.5 Paramics as a Tool for Evaluating the Rules

The advantages of Paramics as a tool for evaluating the differences between the two rules are:

<u>Visualisation</u>

During this research as much was learned from watching the models operating as from analysing the results. In many cases statistical results were counterintuitive and observation of the model revealed a situation that would have otherwise been hard to explain. This would be a very useful feature for road controlling authorities if they needed to review their network to identify areas of concern before a rule change.

The research has highlighted many unknowns such as gap acceptance behaviour that could change under each rule. The results of any traffic modelling are dependent on the input parameters and any assessment of the rules requires some estimation of these parameters and an assumption about whether these will change or not under a rule change. This thesis has investigated the situation with all the parameters constant. This may or may not be the case.

In any event, arriving at a simple mathematical answer to the question of which rule is better has its limitations. The advantage of Paramics or other similar packages is that the network can be observed operating with the changed rule and potential issues can be identified. Were the rule to change, critical locations could be identified beforehand and become the focus of monitoring. Mitigation measures can also be tested for effectiveness should they be deemed necessary.

Stochastic Simulation

The advantage of a stochastic simulation is that the result of the modelling can be different every time. An intersection can break down as a result of different issues. In one run of the model a particular approach queue may cause the breakdown and during the next run another issue may come to light. Watching the model and observing the different events that can happen give a greater understanding of the possible issues that may arise than would be gained from only analysing statistics.

The disadvantages of Paramics as a tool for evaluating the differences between the two rules are:

The Priority System (for minor roads at four-arm intersections)

The overall impact of this on the results was not considered to be significant, as discussed in Section 2.9.2. However it may mean that four-arm priority intersections cannot be as accurately assessed as other intersections. This applies more to the existing situation since changing the rule would bring the priority coding of such intersections inline with practice in other countries. An advantage of a rule change would be that New Zealand would no longer required specialist features from the developers of software such as Paramics and SIDRA.

Overall Paramics has allowed a detailed and insightful investigation into the issue.

8.6 Should the Rule be Changed?

This thesis has shown that the effect of a rule change would be mixed. Intersections with certain features will experience positive effects, intersections with other features will experience negative effects and some intersections will experience little or no effects. For this reason, the intersection performance elements of each rule are likely to remain secondary to the road safety side of the debate.

This research has shown that there appears to be no compelling reason why the rule could not be changed from an intersection performance point of view.

Were the rule to be changed, some mitigation or monitoring measures may need to be put in place to ensure a successful implementation. The research also suggested that some redistribution of vehicle movements is likely in a network situation and this could also be investigated prior to a change to identify and address potential areas of concern.

8.7 Opportunities for Further Research

Opportunities for further research into intersection performance and the New Zealand left turn rule include:

- Investigation into whether SCATS would manage a signalised network differently following a rule change. Such analysis could use baseplusFUSE software which is an interface between a Paramics model and SCATS system. Alternatively a network optimisation software such as Transyt could be used.

- Analysis of the economic costs and benefits across a network using costs such as travel time and vehicle operating costs and comparing these with the estimated road safety benefits.

- An assessment of a city wide situation to investigate how many of the various intersection types there are in the network and what the balance could be between positive, negative and neutral effects.

- Assessment of the rule change pedestrian and vehicle interaction at signalised intersections. A rule change would alter the dynamics of who is required to look at what when turning or crossing. This could be of particular interest at central city intersections with high pedestrian demand.

- An assessment similar to this thesis but using a software package with movement-based dynamic feedback rather than link-based dynamic feedback.

- A comparison of a network operating under each rule and measured using the Paramics pollution modelling and fuel consumption functions.

- An assessment of the driver perspective of the rule change. In reality do drivers perceive right turns as more difficult and unsafe than left turns? Traffic models do no necessarily reflect this. The impact of driver perceptions could be investigated.

9 References

Akcelik, R. (2007). *Microsimulation and Analytical Models for Traffic Engineering*. Presentation at the ARRB - AUSTROADS Microsimulation Forum, Melbourne, September 2007.

Akcelik, R. and Besley M. (1999) *SIDRA 5 User Guide,* ARRB Transport Research Ltd, Victoria.

Allan, R. (1985). *Give Way to the Right: Why the regulations should not have been changed.* Proceedings of technical groups (Transportation and Traffic Engineering Group), Annual Conference of the New Zealand Institution of Engineers (NZIE), Volume 10(3) (Tr), Wellington, February 1985.

Austroads (2006). *The use and application of microsimulation traffic models*, Austroads Research Report APR-286-06, Austroads, Sydney.

Austroads (2005). *Guide to Traffic Engineering Practice: Part 5 – Intersections at Grade* , Austroads, Sydney.

Austroads (2004). *Guide to Traffic Engineering Practice: Part 4- Treatment of Crash Locations,* Austroads, Sydney.

Austroads (1991). *Guide to Traffic Engineering Practice: Part 1- Traffic Flow,* Austroads, Sydney.

Baseplus Limited (2008). Website, www.baseplusworld.com, accessed January 2008

Christchurch City Council (2005), *The Christchurch City District Plan,* Volume 2, Section 7, Transport, Christchurch City Council, Christchurch.

Daltrey, R. A. (1980). *A comparison of alternative rules governing priority between vehicles turning left and right from the same carriageway into an adjoining street.* Australia Road Research, Volume 10 (4), 1980, pp 171-181.

Hughes, T. (1997). *Give Way Rules for Intersections and Driveways*. Presentation to the IPENZ Traffic Management Workshop, Timaru, 1997.

IPENZ Transportation Group Management Committee. (2006). *Our Give Way Rules Must Be Changed.* AA Advocate, Auckland, Issue 15, 2006, pp 24.

Land Transport Safety Authority (2002). *Proposed Land Transport (Road User Rule) - Yellow Draft*, Land Transport Safety Authority, Wellington.

Ministry Transport (2004), *Land Transport (Road User) Rule 2004*, Ministry of Transport, Wellington.

Morgan, R. (1988). *Left Turn Verus Right Turn Priorities - What Can Australia Learn from New Zealand?* Australia Road Research, Volume 18 (1), 1988, pp 11-20.

Parliamentary Counsel Victoria (1993). *Road Safety (Traffic) (Turn Priority) Regulations 1993*, Parliamentary Counsel Victoria, Melbourne.

Quayle, G. M. L. (1979). *Rules of Precedence at Intersections: An examination of alternatives for Australia*, Australian Government Publishing Service, Canberra.

Royce, B., Jurisich, I. and Dunn R. (2006). *Through-lane Use at Traffic Signals*, Land Transport New Zealand Research Report No. 297, Land Transport New Zealand, Wellington.

Seaman, E. (2006). *How to reduce the gambling element of some transport planning decisions.* Traffic Engineering and Control, London, June 2006, pp 220-223.

SIAS Limited (2005). *S-Paramics 2005 Reference Manual*, SIAS Limited, Edinburgh.

Thomson G. and Kammann R. (1979). *Problems of Human Information Processing at Intersections.* Proceedings of technical groups (Transportation and Traffic Engineering Group), 1979 Annual Conference of the New Zealand Institution of Engineers (NZIE), Volume 5 (2), Wellington, February 1979.

Transit New Zealand (2007). *Transit New Zealand's 10-Year State Highway Plan and Forecast for 2007/08 to 2016/17*, Transit New Zealand, Wellington.

10 Bibliography

Land Transport New Zealand (2006). *The Official New Zealand Road Code*, Land Transport New Zealand, Wellington.

Land Transport New Zealand (2008). Website, www.landtransport.govt.nz, accessed February 2008.

Druitt, S. (1998). *An Introduction to Microsimulation*. Traffic Engineering and Control, London, September 1998, pp 480-483.

Morris R. and Sykes P. (2005). *Building and reporting on microsimulation models*. Paper presented at the JCT Traffic Signals Symposium, Nottingham, September 2005.

SIAS Limited (2008). Website, www.sias.com, February 2008.

Transit New Zealand (2005). *Draft State Highway Geometric Design Manual*, Transit New Zealand, Wellington.

APPENDIX A1

Example Data Collection Sheets

Intersection Survey Sheet Barbadoes Street/Warrington Street

Instructions

Count the movements shown on your sheet as

Record light vehicles and heavy vehicles separately

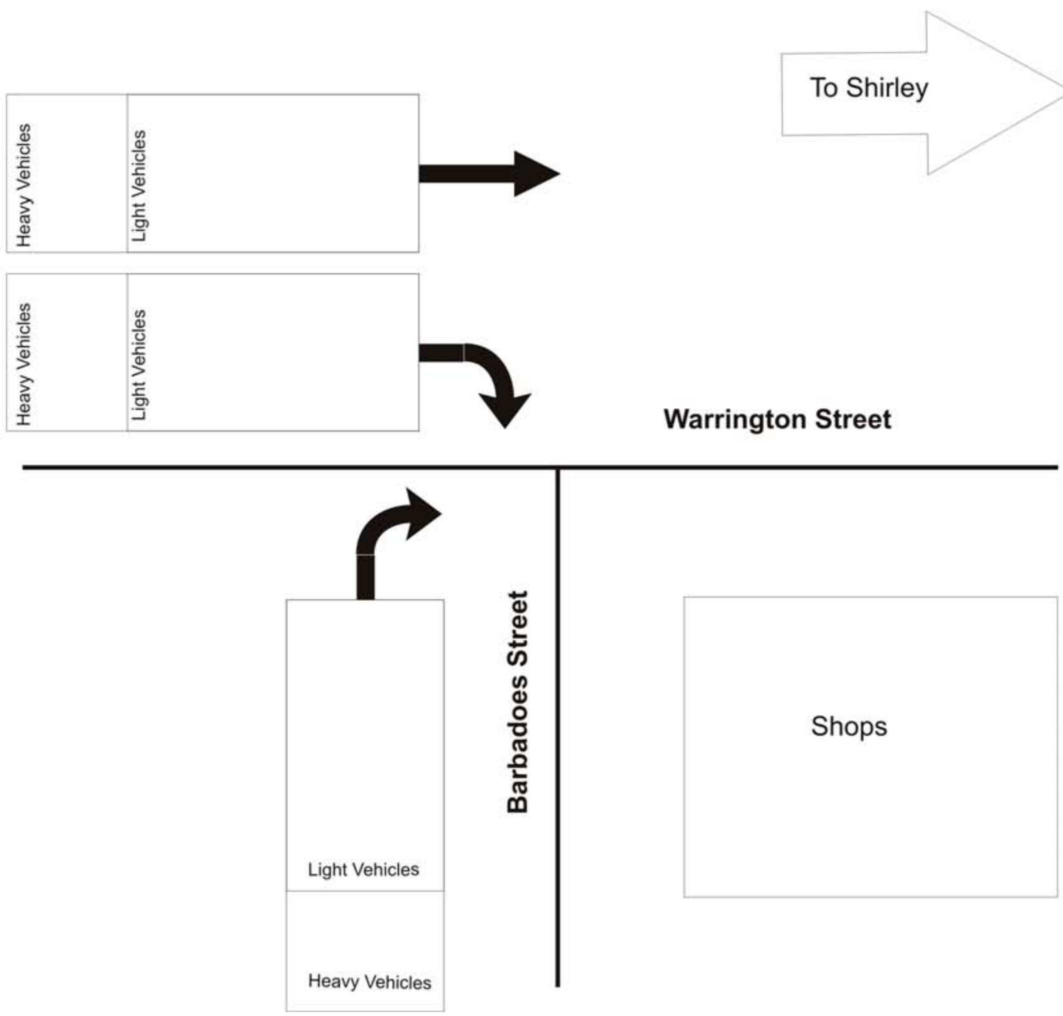
Use a new sheet every 15 minutes

At the end of the survey tally each box and write total as 25

Surveyor Name: ....

Survey Date: ....

Sheet Start Time: ....



Intersection Survey Sheet Riccarton Road/Matipo Street

Instructions

Count the movements shown on your sheet as

Record light vehicles and heavy vehicles separately

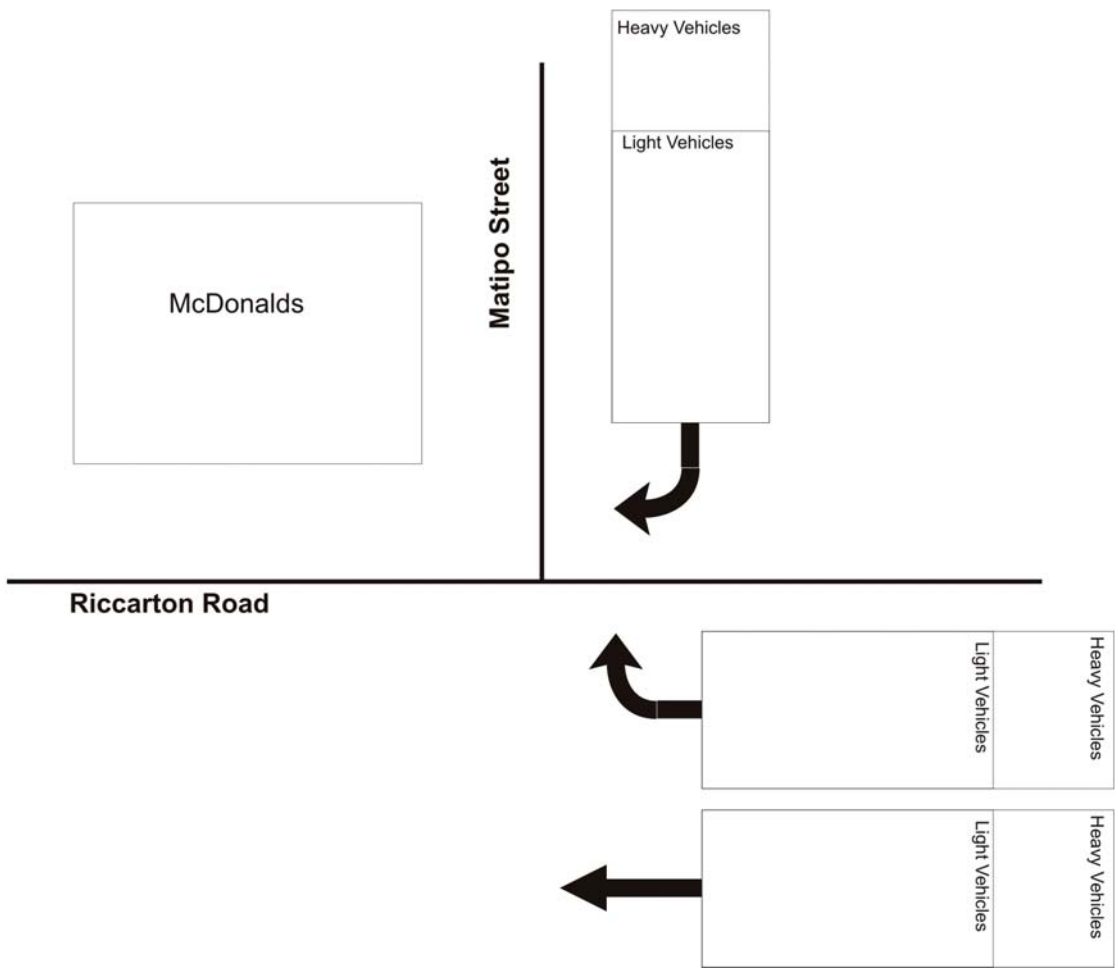
Use a new sheet every 15 minutes

At the end of the survey tally each box and write total as 25

Surveyor Name: ....

Survey Date: ....

Sheet Start Time: ....



Intersection Survey Sheet Papanui Road/Innes Road

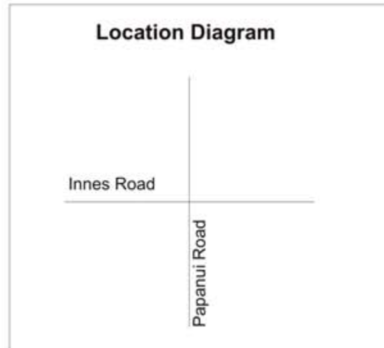
Instructions

Count the movements shown on your sheet as

Record light vehicles and heavy vehicles separately

Use a new sheet every 10 minutes

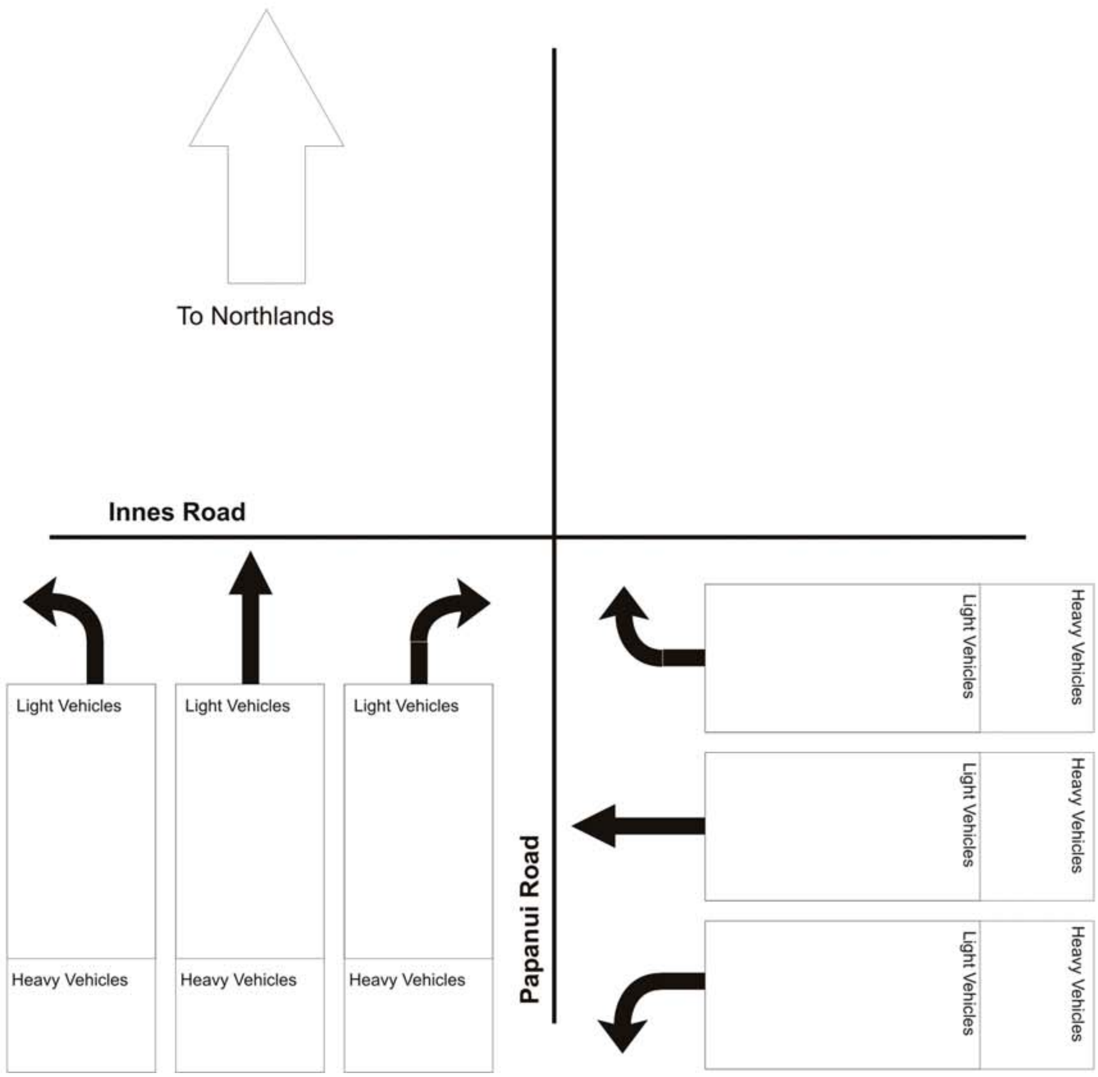
At the end of the survey tally each box and write total as 25



Surveyor Name: ---------------------------

Survey Date: ---------------------------

Sheet Start Time: ---------------------------



APPENDIX A2

CONVERGENCE RESULTS

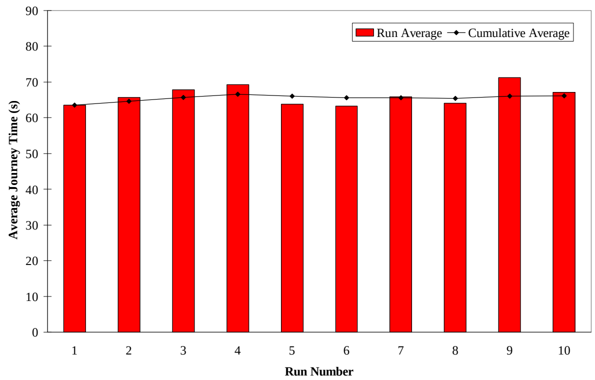


Figure A2.1 – Intersection 2, Breezes Road/Pages Road, Existing Rule

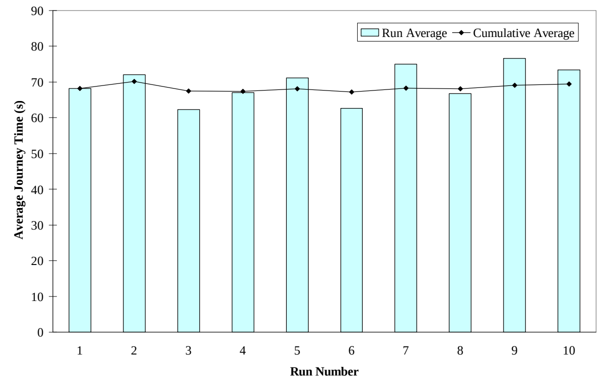


Figure A2.4 – Intersection 2, Breezes Road/Pages Road, Changed Rule

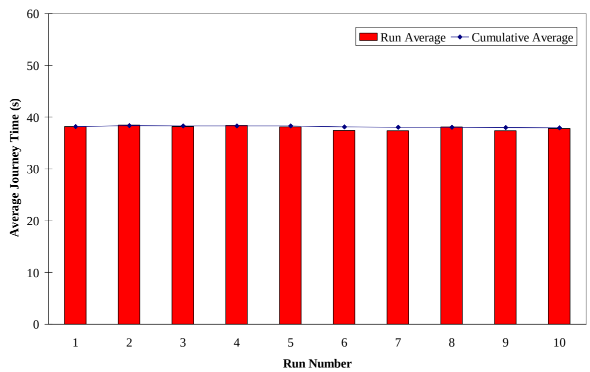


Figure A2.2 – Intersection 3, Marshland Road/The Palms, Existing Rule

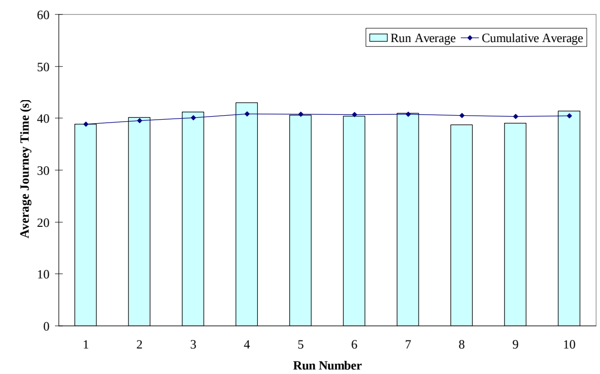


Figure A2.5 – Intersection 3, Marshland Road/The Palms, Changed Rule

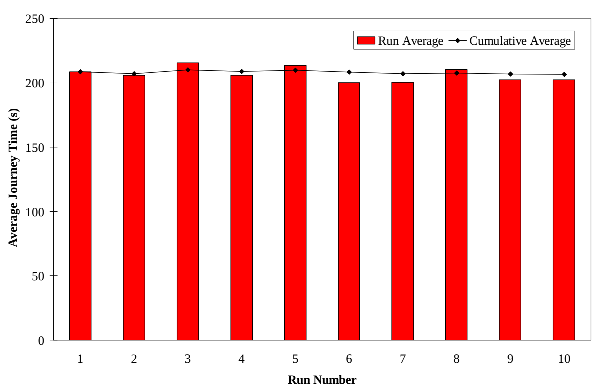


Figure A2.3 – Intersection 4, Bealey Avenue/Colombo Street, Existing Rule

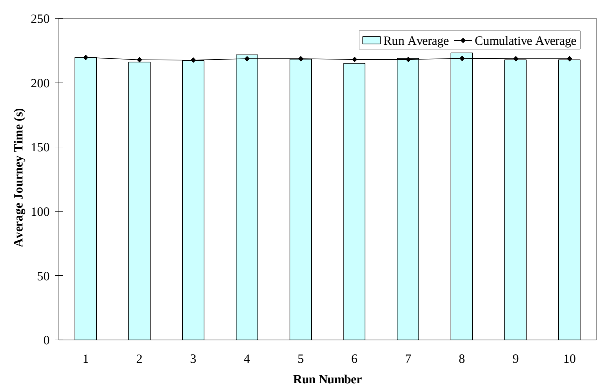


Figure A2.6 – Intersection 4, Bealey Avenue/Colombo Street, Changed Rule

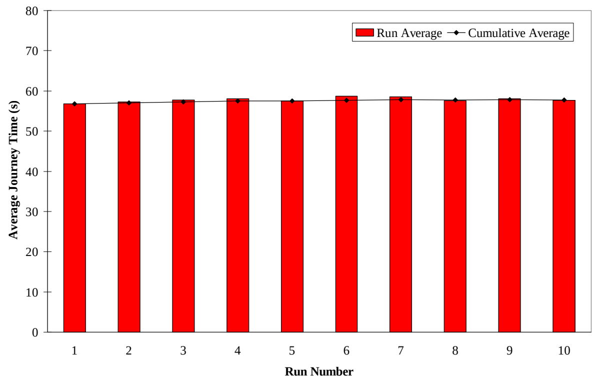


Figure A2.7 – Intersection 5, Main North Road/Prestons Road, Existing Rule

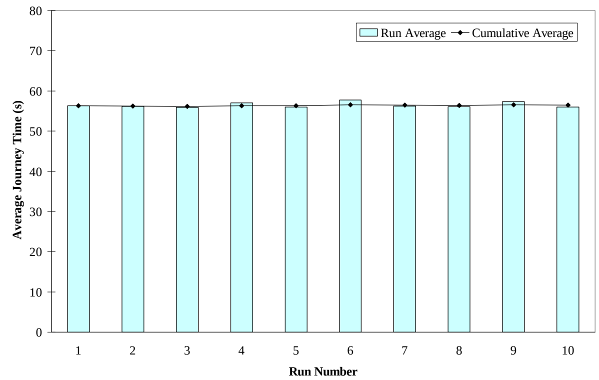


Figure A2.10 – Intersection 5, Main North Road/Prestons Road, Changed Rule

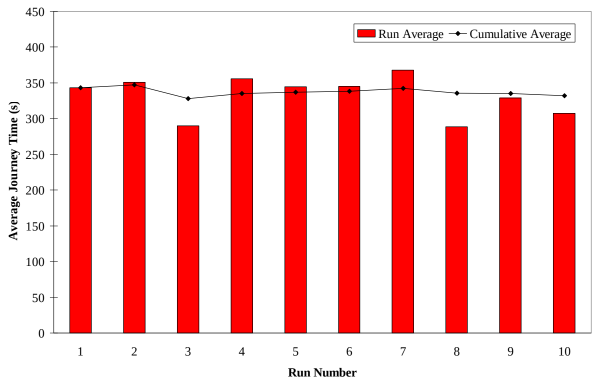


Figure A2.8 – Intersection 6, Innes Road/Papanui Road, Existing Rule

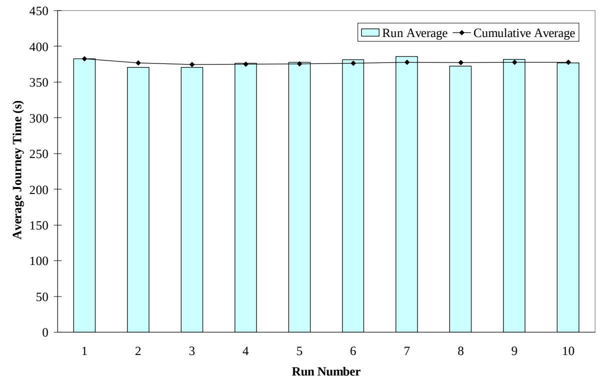


Figure A2.11 – Intersection 6, Innes Road/Papanui Road, Changed Rule

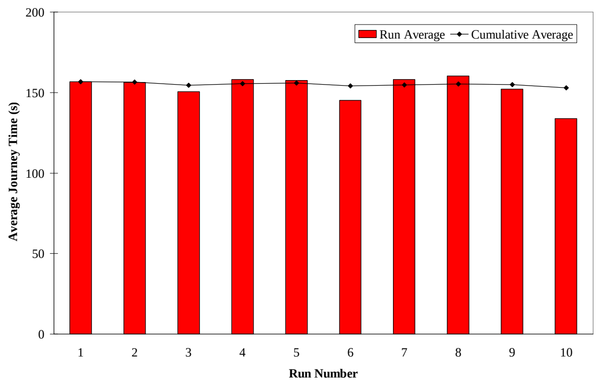


Figure A2.9 – Intersection 7, Blenheim Road/Matipo Street, Existing Rule

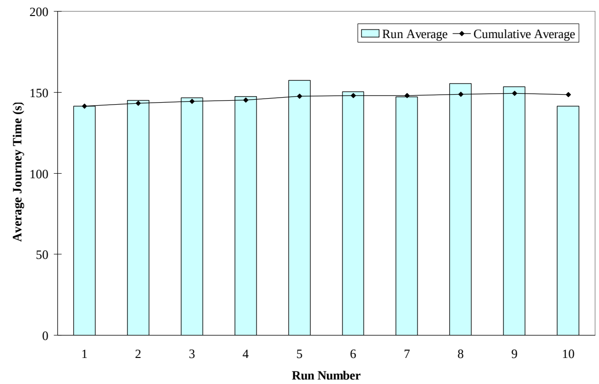


Figure A2.12 – Intersection 7, Blenheim Road/Matipo Street, Changed Rule

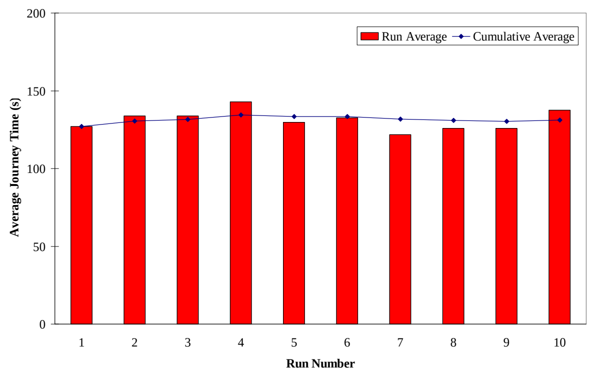


Figure A2.13 – Intersection 8, Matipo Street/Riccarton Road, Existing Rule

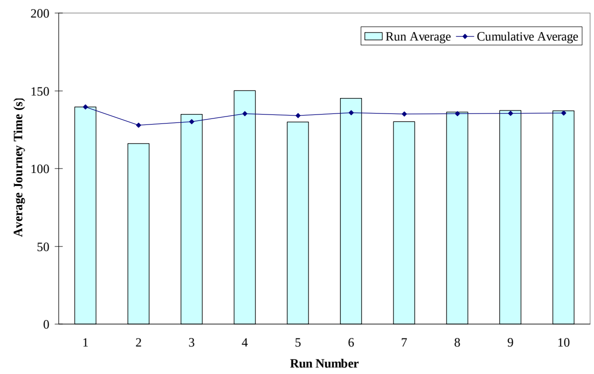


Figure A2.16 – Intersection 8, Matipo Street/Riccarton Road, Changed Rule

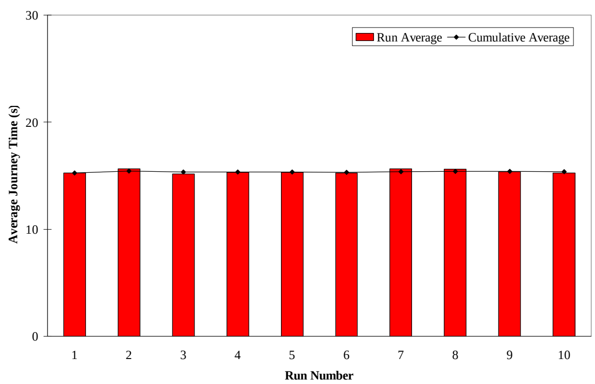


Figure A2.14 – Intersection 9, Colombo Street/Peterborough Street, Existing Rule

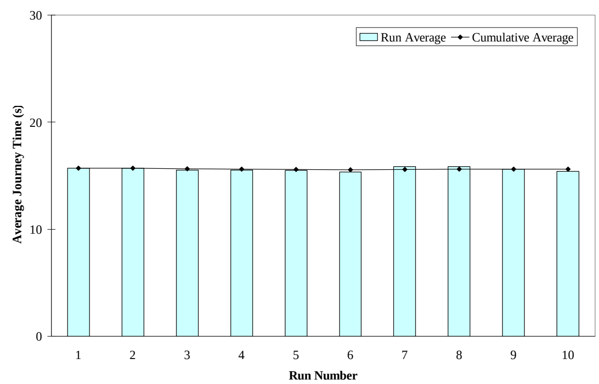


Figure A2.17 – Intersection 9, Colombo Street/Peterborough, Changed Rule

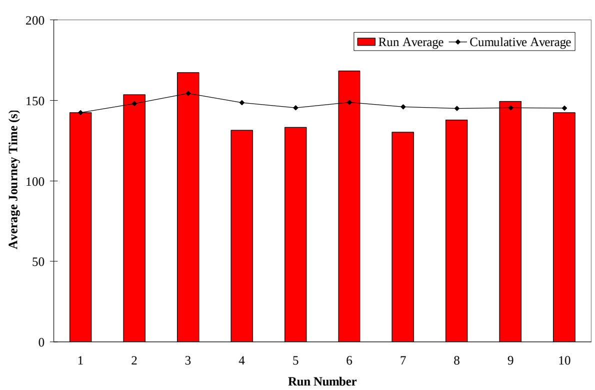


Figure A2.15 – Intersection 10, Halswell Junction Road/Main North Road, Existing Rule

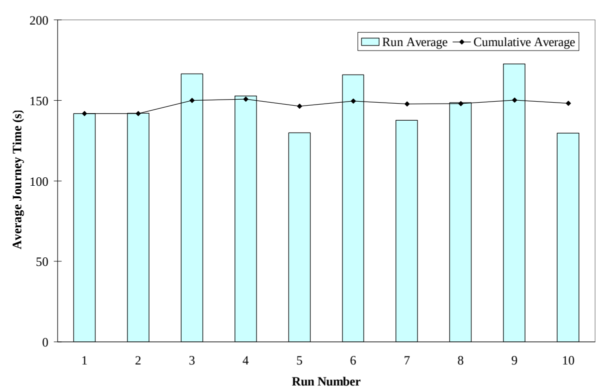


Figure A2.18 – Intersection 10, Halswell Junction Road/Main North Road, Changed Rule

APPENDIX A3

Intersection 1 – Barbadoes Street/Warrington Street Full Data

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A3.1 Approach Photos

Figure A3.1. 1 – Warrington Street East Approach

Figure A3.1. 2 – Barbadoes Street South Approach

Figure A3.1. 3 – Warrington Street West Approach

A3.2 Surveyed Traffic Volumes

Intersection 1: Barbadoes Street/Warrington Street

Survey Date Tuesday, 26 September 2006

Light Vehicles			Barbadoes		Warrington (East)		Warrington (West)		TOTAL
			L	R	T	L	T	R	
3:00	-	3:15	5	14	55	38	69	18	199
3:15	-	3:30	12	38	62	43	92	26	273
3:30	-	3:45	10	17	56	36	91	33	243
3:45	-	4:00	8	16	61	40	51	20	196
4:00	-	4:15	10	26	59	27	100	26	248
4:15	-	4:30	14	21	73	53	77	17	255

Heavy Vehicles			Barbadoes		Warrington (East)		Warrington (West)		TOTAL
			L	R	T	L	T	R	
3:00	-	3:15	0	2	0	0	1	2	5
3:15	-	3:30	0	2	0	3	1	0	6
3:30	-	3:45	0	1	0	3	0	0	4
3:45	-	4:00	0	2	2	2	0	2	8
4:00	-	4:15	0	3	1	0	0	1	5
4:15	-	4:30	0	0	1	4	0	1	6

Total	Barbadoes		Warrington (East)		Warrington (West)	
(3:00pm - 4:30pm)	L	R	T	L	T	R
Light	59	132	366	237	480	140
Heavy	0	10	4	12	2	6

Peak Hour	Barbadoes		Warrington (East)		Warrington (West)	
(3:15pm - 4:15pm)	L	R	T	L	T	R
Light	40	97	238	146	334	105
Heavy	0	8	3	8	1	3

A3.3 Full Journey Time Analysis Results

Method 1 Existing Rule							
Mean Travel Time (seconds)							
Movement			**75**	**100**	**125**	**150**	**175**
WT	Warrington Street (West)	T	19.8	19.8	19.7	19.7	19.7
WR		R	26.9	27.5	28.1	29.4	30.9
SL	Barbadoes Street (South)	L	49.0	50.0	51.1	52.6	138.7
SR		R	54.2	58.7	67.7	84.0	227.1
ET	Warrington Street (East)	T	27.1	27.1	27.2	27.3	27.5
EL		L	34.4	35.3	36.6	37.7	39.2
All Movements	Total Intersection		29.4	30.1	31.3	33.3	50.7
Median Travel Time (seconds)							
Movement			**75**	**100**	**125**	**150**	**175**
WT	Warrington Street (West)	T	20.0	20.0	20.0	20.0	20.0
WR		R	26.0	26.0	26.0	28.0	29.0
SL	Barbadoes Street (South)	L	48.0	49.0	49.0	51.0	73.0
SR		R	51.0	54.0	63.0	75.0	197.0
ET	Warrington Street (East)	T	27.0	27.0	27.0	27.0	27.0
EL		L	32.0	33.0	34.0	35.0	36.0
All Movements	Total Intersection		27.0	27.0	27.0	27.0	27.0
15-Percentile Travel Time (seconds)							
Movement			**75**	**100**	**125**	**150**	**175**
WT	Warrington Street (West)	T	20.0	19.0	19.0	19.0	19.0
WR		R	26.0	26.0	26.0	26.0	26.0
SL	Barbadoes Street (South)	L	48.0	48.0	48.0	48.0	49.0
SR		R	48.0	49.0	50.0	54.0	80.0
ET	Warrington Street (East)	T	27.0	27.0	27.0	27.0	27.0
EL		L	32.0	32.0	32.0	32.0	32.0
All Movements	Total Intersection		20.0	20.0	20.0	20.0	20.0
85-Percentile Travel Time (seconds)							
Movement			**75**	**100**	**125**	**150**	**175**
WT	Warrington Street (West)	T	20.0	20.0	20.0	20.0	20.0
WR		R	29.0	30.0	31.0	34.0	37.0
SL	Barbadoes Street (South)	L	51.0	53.0	54.0	58.0	282.0
SR		R	62.0	69.0	85.0	117.6	393.8
ET	Warrington Street (East)	T	27.0	27.0	27.0	28.0	28.0
EL		L	38.0	40.0	43.0	44.0	47.0
All Movements	Total Intersection		43.0	44.0	47.0	48.0	50.0

Method 1 Changed Rule							
Mean Travel Time (seconds)							
Movement			**75**	**100**	**125**	**150**	**175**
WT	Warrington Street (West)	T	19.8	19.8	19.7	19.7	19.9
WR		R	29.7	32.0	35.5	43.4	55.5
SL	Barbadoes Street (South)	L	49.1	50.0	51.0	65.6	546.9
SR		R	55.6	61.6	75.3	126.9	686.3
ET	Warrington Street (East)	T	27.1	27.1	27.1	27.1	27.1
EL		L	30.2	30.2	30.3	30.3	30.3
All Movements	Total Intersection		29.1	29.9	31.7	38.0	98.0
Median Travel Time (seconds)							
Movement			**75**	**100**	**125**	**150**	**175**
WT	Warrington Street (West)	T	20.0	20.0	20.0	20.0	20.0
WR		R	27.0	29.0	32.0	38.0	48.0
SL	Barbadoes Street (South)	L	48.0	49.0	49.0	53.0	645.0
SR		R	52.0	57.0	70.0	102.0	797.0
ET	Warrington Street (East)	T	27.0	27.0	27.0	27.0	27.0
EL		L	30.0	30.0	30.0	30.0	30.0
All Movements	Total Intersection		27.0	27.0	27.0	27.0	27.0
15-Percentile Travel Time (seconds)							
Movement			**75**	**100**	**125**	**150**	**175**
WT	Warrington Street (West)	T	20.0	19.0	19.0	19.0	19.0
WR		R	26.0	26.0	26.0	27.0	30.0
SL	Barbadoes Street (South)	L	48.0	48.0	48.0	48.0	55.0
SR		R	48.0	49.0	51.0	62.0	148.0
ET	Warrington Street (East)	T	27.0	27.0	27.0	27.0	27.0
EL		L	30.0	30.0	30.0	30.0	30.0
All Movements	Total Intersection		20.0	20.0	20.0	20.0	20.0
85-Percentile Travel Time (seconds)							
Movement			**75**	**100**	**125**	**150**	**175**
WT	Warrington Street (West)	T	20.0	20.0	20.0	20.0	20.0
WR		R	35.0	40.0	46.0	62.0	81.0
SL	Barbadoes Street (South)	L	51.0	53.0	55.0	76.0	893.7
SR		R	65.0	76.0	100.0	198.0	1035.0
ET	Warrington Street (East)	T	27.0	27.0	27.0	27.0	27.0
EL		L	31.0	31.0	31.0	31.0	31.0
All Movements	Total Intersection		36.5	41.0	47.0	50.0	55.0

Method 2 Existing Rule

Mean Travel Time (seconds)

Movement			**50**	**100**	**150**	**200**	**300**
WT	Warrington Street (West)	T	19.8	19.8	19.7	19.8	19.7
WR		R	27.3	27.5	27.7	28.0	28.6
SL	Barbadoes Street (South)	L	50.1	50.0	50.0	49.5	48.4
SR		R	55.6	58.7	61.7	64.8	69.0
ET	Warrington Street (East)	T	27.1	27.1	27.1	27.2	27.2
EL		L	33.8	35.3	36.8	38.6	42.2
All Movements	Total Intersection		30.0	30.1	30.1	30.1	29.8

Median Travel Time (seconds)

Movement			**50**	**100**	**150**	**200**	**300**
WT	Warrington Street (West)	T	20.0	20.0	20.0	20.0	20.0
WR		R	26.0	26.0	26.0	26.0	27.0
SL	Barbadoes Street (South)	L	49.0	49.0	49.0	48.0	48.0
SR		R	53.0	54.0	57.0	60.0	66.0
ET	Warrington Street (East)	T	27.0	27.0	27.0	27.0	27.0
EL		L	32.0	33.0	34.0	35.0	39.0
All Movements	Total Intersection		27.0	27.0	27.0	27.0	27.0

15-Percentile Travel Time (seconds)

Movement			**50**	**100**	**150**	**200**	**300**
WT	Warrington Street (West)	T	20.0	19.0	19.0	19.0	19.0
WR		R	26.0	26.0	26.0	26.0	26.0
SL	Barbadoes Street (South)	L	48.0	48.0	48.0	48.0	47.0
SR		R	48.0	49.0	49.0	49.0	50.0
ET	Warrington Street (East)	T	27.0	27.0	27.0	27.0	27.0
EL		L	32.0	32.0	32.0	32.0	32.0
All Movements	Total Intersection		20.0	20.0	20.0	20.0	20.0

85-Percentile Travel Time (seconds)

Movement			**50**	**100**	**150**	**200**	**300**
WT	Warrington Street (West)	T	20.0	20.0	20.0	20.0	20.0
WR		R	30.0	30.0	30.0	31.0	32.0
SL	Barbadoes Street (South)	L	53.0	53.0	53.0	53.0	49.0
SR		R	64.9	69.0	76.0	81.0	87.0
ET	Warrington Street (East)	T	27.0	27.0	27.0	27.0	27.0
EL		L	36.0	40.0	43.0	47.0	54.0
All Movements	Total Intersection		48.0	44.0	41.0	40.0	36.0

Method 2 Changed Rule							
Mean Travel Time (seconds)							
Movement			**50**	**100**	**150**	**200**	**300**
WT	Warrington Street (West)	T	19.8	19.8	19.8	19.8	19.7
WR		R	31.7	32.0	32.2	33.1	33.8
SL	Barbadoes Street (South)	L	50.1	50.0	50.0	49.6	48.4
SR		R	57.3	61.6	65.4	69.5	73.4
ET	Warrington Street (East)	T	27.1	27.1	27.1	27.1	27.1
EL		L	30.2	30.2	30.2	30.2	30.2
All Movements	Total Intersection		29.8	29.9	30.0	30.2	30.0
Median Travel Time (seconds)							
Movement			**50**	**100**	**150**	**200**	**300**
WT	Warrington Street (West)	T	20.0	20.0	20.0	20.0	20.0
WR		R	29.0	29.0	29.0	30.0	31.0
SL	Barbadoes Street (South)	L	49.0	49.0	49.0	48.0	48.0
SR		R	53.0	57.0	61.0	66.0	71.0
ET	Warrington Street (East)	T	27.0	27.0	27.0	27.0	27.0
EL		L	30.0	30.0	30.0	30.0	30.0
All Movements	Total Intersection		27.0	27.0	27.0	27.0	27.0
15-Percentile Travel Time (seconds)							
Movement			**50**	**100**	**150**	**200**	**300**
WT	Warrington Street (West)	T	20.0	19.0	19.0	19.0	19.0
WR		R	26.0	26.0	26.0	26.0	26.0
SL	Barbadoes Street (South)	L	48.0	48.0	48.0	48.0	47.0
SR		R	48.0	49.0	49.0	50.0	52.0
ET	Warrington Street (East)	T	27.0	27.0	27.0	27.0	27.0
EL		L	30.0	30.0	30.0	30.0	30.0
All Movements	Total Intersection		20.0	20.0	20.0	20.0	20.0
85-Percentile Travel Time (seconds)							
Movement			**50**	**100**	**150**	**200**	**300**
WT	Warrington Street (West)	T	20.0	20.0	20.0	20.0	20.0
WR		R	39.0	40.0	40.0	41.0	42.0
SL	Barbadoes Street (South)	L	54.0	53.0	53.0	53.0	49.0
SR		R	69.0	76.0	83.0	88.0	92.0
ET	Warrington Street (East)	T	27.0	27.0	27.0	27.0	27.0
EL		L	31.0	31.0	31.0	31.0	31.0
All Movements	Total Intersection		48.0	41.0	37.0	36.0	36.0

A3.4 Full Queue Length Analysis Results

Method 1							
Existing Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
E1	Warrington Street (East)	L	1.1	1.2	1.3	1.4	1.5
E2		T	0.0	0.0	0.0	0.0	0.0
S1	Barbadoes Street (South)	L	1.0	1.0	1.2	1.3	9.7
S2		R	1.1	1.3	1.5	2.2	4.9
W1	Warrington Street (West)	T	0.0	0.0	0.0	0.0	0.0
W2		R	1.0	1.1	1.1	1.1	1.3
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
E1	Warrington Street (East)	L	2.4	3.3	4.0	4.6	5.5
E2		T	0.0	0.0	0.0	0.0	0.0
S1	Barbadoes Street (South)	L	1.1	1.4	2.2	3.3	23.9
S2		R	2.3	3.3	5.0	6.5	8.0
W1	Warrington Street (West)	T	0.0	0.0	0.0	0.0	0.0
W2		R	1.8	2.1	2.3	2.8	3.9
Changed Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
E1	Warrington Street (East)	L	1.0	1.0	1.0	1.0	1.0
E2		T	0.0	0.0	0.0	0.0	0.0
S1	Barbadoes Street (South)	L	1.0	1.0	1.1	3.0	32.0
S2		R	1.1	1.3	1.8	3.5	6.1
W1	Warrington Street (West)	T	0.0	0.0	0.0	0.0	0.0
W2		R	1.1	1.1	1.3	1.7	2.3
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
E1	Warrington Street (East)	L	1.0	1.0	1.0	1.0	1.0
E2		T	0.0	0.0	0.0	0.0	0.0
S1	Barbadoes Street (South)	L	1.1	1.3	2.1	8.6	61.4
S2		R	2.4	3.7	5.4	7.9	8.1
W1	Warrington Street (West)	T	0.0	0.0	0.0	0.0	0.0
W2		R	2.4	2.8	3.6	6.1	7.3

Method 2							
Existing Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
E1	Warrington Street (East)	L	1.2	1.2	1.2	1.2	1.2
E2		T	0.0	0.0	0.0	0.0	0.0
S1	Barbadoes Street (South)	L	1.0	1.0	1.0	1.0	1.0
S2		R	1.2	1.3	1.3	1.3	1.2
W1	Warrington Street (West)	T	0.0	0.0	0.0	0.0	0.0
W2		R	1.0	1.1	1.1	1.2	1.2
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
E1	Warrington Street (East)	L	2.9	3.3	3.0	3.5	3.6
E2		T	0.0	0.0	0.0	0.0	0.0
S1	Barbadoes Street (South)	L	1.8	1.4	1.2	1.0	1.0
S2		R	3.2	3.3	3.6	3.3	2.9
W1	Warrington Street (West)	T	0.0	0.0	0.0	0.0	0.0
W2		R	1.2	2.1	2.7	2.9	3.6
Changed Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
E1	Warrington Street (East)	L	0.0	1.0	0.0	0.0	0.0
E2		T	0.0	0.0	0.0	0.0	0.0
S1	Barbadoes Street (South)	L	1.0	1.0	1.0	1.0	1.0
S2		R	1.2	1.3	1.3	1.3	1.2
W1	Warrington Street (West)	T	0.0	0.0	0.0	0.0	0.0
W2		R	1.1	1.1	1.2	1.4	1.6
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
E1	Warrington Street (East)	L	0.0	1.0	0.0	0.0	0.0
E2		T	0.0	0.0	0.0	0.0	0.0
S1	Barbadoes Street (South)	L	1.8	1.3	1.2	1.0	1.0
S2		R	3.4	3.7	3.9	3.4	3.1
W1	Warrington Street (West)	T	0.0	0.0	0.0	0.0	0.0
W2		R	1.9	2.8	3.3	4.3	5.9

APPENDIX A4

Intersection 2 – Breezes Road/Pages Road Full Data

Table of Contents

A4.1 Approach Photos

Figure A4.1. 1 - Breezes Road North Approach

Figure A4.1. 2 - Pages Road East Approach

Figure A4.1. 3 - Breezes Road South Approach

Figure A4.1. 4 - Pages Road West Approach

A4.2 Surveyed Traffic Volume Data

Intersection 2: Breezes Road/Pages Road

Survey Date Monday, 2 October 2006

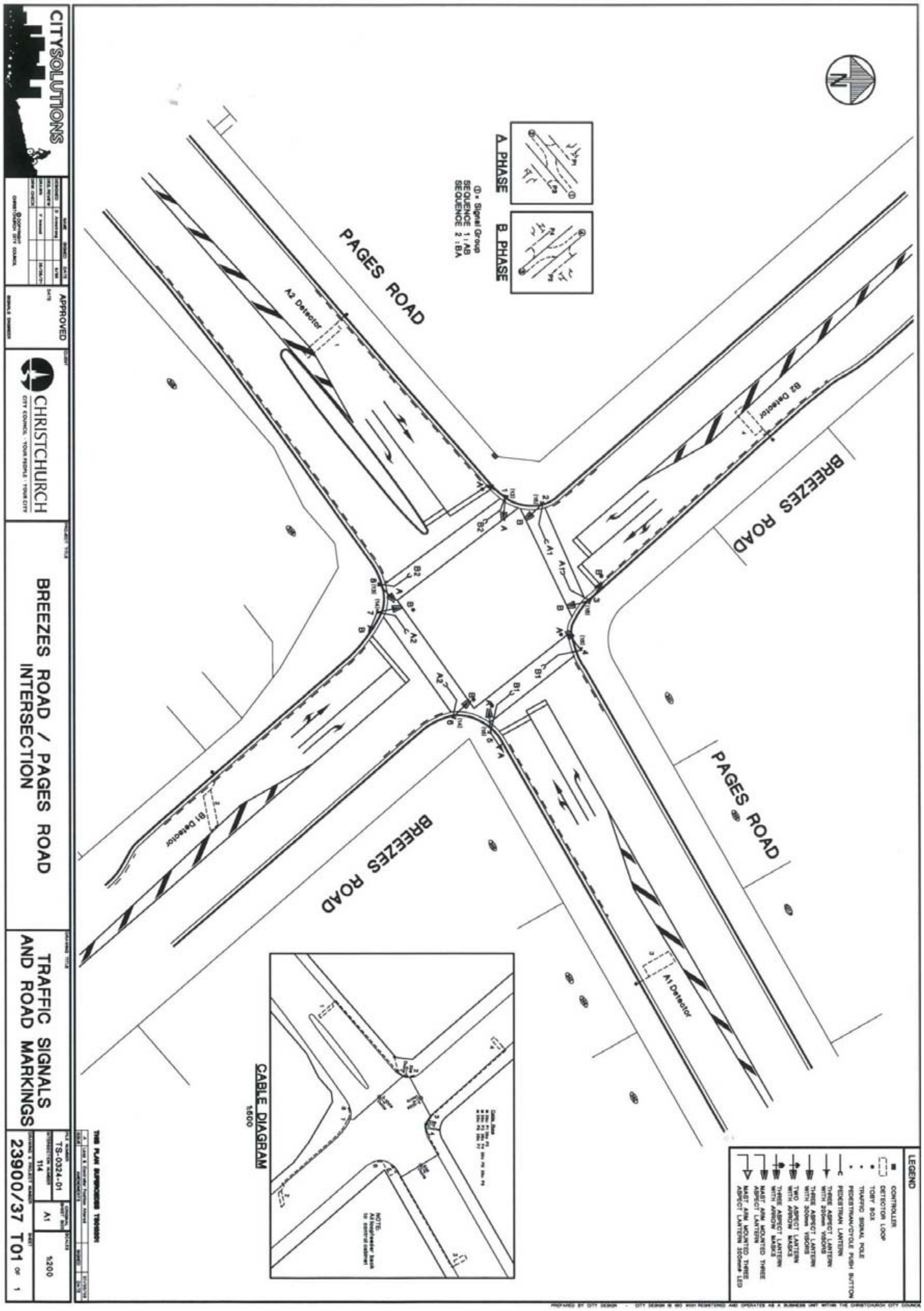
Light Vehicles			Breezes (South)			Pages (East)			Breezes (North)			Pages (West)			TOTAL
			L	T	R	L	T	R	L	T	R	L	T	R	
4:30	-	4:45	14	66	3	2	48	17	2	21	7	8	47	15	250
4:45	-	5:00	18	49	6	6	51	14	8	21	7	7	49	5	241
5:00	-	5:15	32	77	15	11	71	16	12	16	16	21	82	18	387
5:15	-	5:30	36	64	14	7	90	15	7	22	13	22	93	12	395
5:30	-	5:45	26	70	14	2	72	17	16	19	22	27	90	17	392
5:45	-	6:00	21	79	16	6	34	19	11	26	16	9	86	17	340

Heavy Vehicles			Breezes (South)			Pages (East)			Breezes (North)			Pages (West)			TOTAL
			L	T	R	L	T	R	L	T	R	L	T	R	
4:30	-	4:45	1	0	0	0	0	0	0	2	0	0	0	0	3
4:45	-	5:00	0	0	0	0	0	1	0	0	0	0	0	0	1
5:00	-	5:15	1	0	0	0	4	0	0	1	0	1	5	1	13
5:15	-	5:30	1	0	0	0	3	0	0	1	1	1	2	0	9
5:30	-	5:45	1	0	0	1	3	0	0	2	0	1	4	0	12
5:45	-	6:00	0	2	0	2	4	0	0	2	1	2	3	0	16

Total	Breezes (South)			Pages (East)			Breezes (North)			Pages (West)		
(4:30pm - 6:00pm)	L	T	R	L	T	R	L	T	R	L	T	R
Light	147	405	68	34	366	98	56	125	81	94	447	84
Heavy	4	2	0	3	14	1	0	8	2	5	14	1

Peak Hour	Breezes (South)			Pages (East)			Breezes (North)			Pages (West)		
(4:45pm - 5:45pm)	L	T	R	L	T	R	L	T	R	L	T	R
Light	112	260	49	26	284	62	43	78	58	77	314	52
Heavy	3	0	0	1	10	1	0	4	1	3	11	1

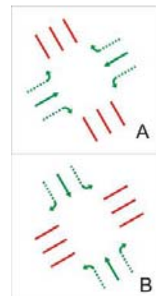
A4.3 Traffic Signal Plan



A4.4 Observed and Modelled Signal Timings

Intersection 2 Breezes Road/Pages Road (SCATS ID = 114)

Traffic Count Day		Monday 2 October, 2006		
Observed Signal Day		Thursday 14 September, 2006		
Observed Time Period		4:30pm to 6:00pm		
Observed Phase Timings				
Phase	Count	Minimum (s)	Maximum (s)	Average (s)
A	96	13	72	34
B	96	11	37	22
Cycle	-	-	-	56
Modelled Phase Timings				
A	-	-	-	38
B	-	-	-	32
Cycle	-	-	-	70



A4.5 Full Journey Time Analysis Results

Method 1 Existing Rule							
Mean Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Breezes Road (North)	L	61.6	62.8	62.2	64.3	66.8
NT		T	57.2	57.4	57.8	59.0	60.5
NR		R	67.2	69.9	74.2	87.5	124.9
EL	Pages Road (East)	L	65.0	65.3	66.8	67.3	69.0
ET		T	62.5	63.4	64.7	65.4	67.2
ER		R	66.7	68.8	70.2	73.9	77.7
SL	Breezes Road (South)	L	53.3	54.0	56.2	59.0	62.7
ST		T	48.8	49.9	50.6	52.2	55.9
SR		R	53.3	53.3	54.2	55.1	58.2
WL	Pages Road (West)	L	50.6	51.8	53.7	57.0	69.9
WT		T	47.5	48.0	49.3	52.1	64.4
WR		R	49.1	50.3	51.7	55.5	66.1
All Movements		All	54.8	55.7	57.0	59.4	66.2
Median Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Breezes Road (North)	L	55.0	58.0	58.0	61.0	63.0
NT		T	51.0	52.0	53.0	55.0	56.0
NR		R	62.0	66.0	71.0	82.0	104.0
EL	Pages Road (East)	L	61.0	61.0	64.0	64.0	67.0
ET		T	56.0	58.0	62.0	62.0	65.0
ER		R	62.0	65.0	66.0	71.0	74.0
SL	Breezes Road (South)	L	49.0	51.0	54.0	58.0	61.0
ST		T	43.0	46.0	48.0	50.0	54.0
SR		R	48.0	47.0	49.0	50.0	55.0
WL	Pages Road (West)	L	46.0	47.0	51.0	55.0	66.0
WT		T	42.0	43.0	46.0	50.0	60.0
WR		R	43.0	45.0	47.0	52.0	61.0
All Movements		All	52.0	53.0	55.0	57.0	62.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Breezes Road (North)	L	49.0	49.0	49.0	49.0	49.0
NT		T	43.0	43.0	43.0	43.0	43.0
NR		R	51.0	52.0	52.0	54.0	61.0
EL	Pages Road (East)	L	53.0	53.0	53.0	54.0	54.0
ET		T	51.0	51.0	51.0	51.0	52.0
ER		R	55.0	55.0	55.0	57.0	58.0
SL	Breezes Road (South)	L	39.0	40.0	40.0	41.0	42.0
ST		T	34.0	34.0	34.0	34.0	35.0
SR		R	40.0	40.0	40.0	41.0	41.0
WL	Pages Road (West)	L	40.0	40.0	40.0	40.0	42.0
WT		T	35.0	35.0	35.0	36.0	37.0
WR		R	39.0	39.0	39.0	39.0	42.0
All Movements		All	36.0	37.0	38.0	40.0	43.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Breezes Road (North)	L	80.0	82.0	80.0	83.0	86.0
NT		T	78.0	78.0	78.7	79.0	81.5
NR		R	89.0	91.0	97.0	116.2	193.0
EL	Pages Road (East)	L	82.0	83.0	82.0	84.0	86.0
ET		T	80.0	81.0	82.0	83.0	84.0
ER		R	83.0	85.0	88.0	91.0	98.0
SL	Breezes Road (South)	L	72.0	71.0	74.0	77.0	80.0
ST		T	70.0	70.0	71.0	72.0	76.0
SR		R	72.0	72.0	74.0	75.0	78.0
WL	Pages Road (West)	L	67.0	69.0	70.0	74.0	96.0
WT		T	65.0	66.0	66.0	70.0	89.0
WR		R	65.0	67.2	68.9	71.0	91.0
All Movements		All	73.0	74.0	76.0	78.0	85.0

Method 1 Changed Rule							
Mean Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Breezes Road (North)	L	58.9	59.3	58.4	59.9	87.7
NT		T	56.7	56.8	56.9	57.7	84.1
NR		R	67.8	71.0	75.2	98.0	226.7
EL	Pages Road (East)	L	62.5	62.5	63.9	63.5	67.9
ET		T	62.3	63.1	64.3	64.4	68.7
ER		R	67.2	71.3	73.9	85.6	119.1
SL	Breezes Road (South)	L	51.3	51.6	53.2	54.5	54.9
ST		T	48.7	49.8	50.4	51.5	52.2
SR		R	53.7	53.8	54.8	56.4	58.3
WL	Pages Road (West)	L	47.7	48.1	48.9	49.7	51.1
WT		T	46.9	47.1	47.7	48.3	49.5
WR		R	49.3	50.5	52.6	55.8	65.4
All Movements		All	54.3	55.1	56.2	58.5	69.5
Median Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Breezes Road (North)	L	52.0	53.0	53.0	56.0	66.0
NT		T	50.0	51.0	51.0	53.0	64.0
NR		R	63.0	67.0	72.0	89.0	192.0
EL	Pages Road (East)	L	58.0	56.0	61.0	59.0	64.0
ET		T	56.0	58.0	61.0	60.0	64.0
ER		R	62.0	67.0	70.0	79.0	95.0
SL	Breezes Road (South)	L	46.0	47.0	50.0	53.0	53.0
ST		T	43.0	46.0	47.0	49.0	50.0
SR		R	48.0	47.0	49.0	52.0	54.0
WL	Pages Road (West)	L	42.0	42.0	43.0	45.0	49.0
WT		T	41.0	41.0	43.0	45.0	47.0
WR		R	43.0	46.0	48.0	52.0	59.0
All Movements		All	52.0	52.0	53.0	54.0	57.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Breezes Road (North)	L	46.0	46.0	46.0	46.0	46.0
NT		T	43.0	43.0	43.0	43.0	43.0
NR		R	51.0	52.0	52.0	55.0	70.0
EL	Pages Road (East)	L	51.0	51.0	51.0	52.0	52.0
ET		T	51.0	51.0	51.0	51.0	52.0
ER		R	55.0	55.0	56.0	58.0	62.0
SL	Breezes Road (South)	L	38.0	38.0	38.0	38.0	39.0
ST		T	34.0	34.0	34.0	34.0	35.0
SR		R	40.0	40.0	40.0	41.0	41.0
WL	Pages Road (West)	L	37.0	37.0	37.0	37.0	37.0
WT		T	35.0	35.0	35.0	35.0	35.0
WR		R	39.0	39.0	39.0	39.0	40.9
All Movements		All	36.0	37.0	37.0	38.0	38.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Breezes Road (North)	L	78.0	79.0	77.0	78.1	122.3
NT		T	77.0	77.0	77.0	77.0	110.0
NR		R	90.0	92.0	98.3	141.0	403.9
EL	Pages Road (East)	L	80.0	80.0	80.0	79.0	83.0
ET		T	80.0	81.0	82.0	82.0	85.0
ER		R	85.0	89.0	93.0	111.9	181.0
SL	Breezes Road (South)	L	71.0	69.0	72.0	72.0	72.0
ST		T	70.0	70.0	71.0	71.0	71.0
SR		R	72.0	73.0	75.0	76.0	78.0
WL	Pages Road (West)	L	65.0	65.0	66.0	67.5	68.6
WT		T	65.0	65.0	65.0	66.0	66.0
WR		R	66.0	68.0	70.0	72.0	89.1
All Movements		All	73.0	74.0	75.0	77.0	81.0

Method 2 Existing Rule							
Mean Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Breezes Road (North)	L	63.3	62.8	62.7	63.5	65.7
NT		T	57.2	57.4	56.4	57.7	57.3
NR		R	69.6	69.9	69.6	69.4	71.7
EL	Pages Road (East)	L	65.2	65.3	65.0	65.7	67.6
ET		T	63.7	63.4	62.9	63.2	63.1
ER		R	68.0	68.8	69.3	69.2	70.2
SL	Breezes Road (South)	L	53.8	54.0	54.3	53.9	55.4
ST		T	49.7	49.9	49.1	49.5	48.4
SR		R	54.4	53.3	55.1	54.0	54.5
WL	Pages Road (West)	L	51.2	51.8	53.5	52.9	54.5
WT		T	48.0	48.0	48.2	47.5	47.2
WR		R	48.8	50.3	50.5	50.3	51.4
All Movements		All	55.1	55.7	56.2	56.8	58.6
Median Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Breezes Road (North)	L	60.0	58.0	57.0	59.0	61.0
NT		T	52.0	52.0	50.0	51.0	51.0
NR		R	63.0	66.0	66.0	66.0	70.0
EL	Pages Road (East)	L	60.0	61.0	62.0	62.0	65.0
ET		T	58.0	58.0	57.0	58.0	57.0
ER		R	64.0	65.0	66.0	66.0	66.0
SL	Breezes Road (South)	L	51.0	51.0	50.0	50.0	52.0
ST		T	46.0	46.0	45.0	45.0	42.0
SR		R	47.0	47.0	50.0	48.0	49.0
WL	Pages Road (West)	L	47.0	47.0	50.0	50.0	51.0
WT		T	44.0	43.0	43.0	42.0	41.0
WR		R	44.0	45.0	46.0	46.0	46.0
All Movements		All	53.0	53.0	54.0	54.0	56.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Breezes Road (North)	L	49.0	49.0	49.0	49.0	49.0
NT		T	43.0	43.0	43.0	43.0	43.0
NR		R	51.0	52.0	51.0	51.0	52.0
EL	Pages Road (East)	L	53.0	53.0	53.0	53.0	53.0
ET		T	51.0	51.0	51.0	51.0	51.0
ER		R	55.0	55.0	55.7	55.0	55.0
SL	Breezes Road (South)	L	40.0	40.0	40.0	40.0	40.0
ST		T	34.0	34.0	34.0	34.0	34.0
SR		R	40.0	40.0	40.0	40.0	41.0
WL	Pages Road (West)	L	40.0	40.0	40.0	40.0	40.0
WT		T	35.0	35.0	35.0	35.0	35.0
WR		R	39.0	39.0	39.0	39.0	39.0
All Movements		All	37.0	37.0	38.0	38.0	39.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Breezes Road (North)	L	83.0	82.0	82.0	84.0	85.0
NT		T	76.0	78.0	76.0	78.0	78.0
NR		R	91.0	91.0	90.0	90.0	92.0
EL	Pages Road (East)	L	82.0	83.0	81.0	81.0	85.0
ET		T	82.0	81.0	81.0	81.0	81.0
ER		R	85.0	85.0	86.0	86.0	88.0
SL	Breezes Road (South)	L	72.0	71.0	71.0	71.0	74.0
ST		T	70.0	70.0	69.0	70.0	69.0
SR		R	74.0	72.0	76.0	74.0	74.0
WL	Pages Road (West)	L	67.0	69.0	70.0	68.0	71.0
WT		T	65.0	66.0	66.0	65.0	65.0
WR		R	63.0	67.2	67.0	66.0	68.0
All Movements		All	74.0	74.0	75.0	76.0	79.0

Method 2 Changed Rule							
Mean Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Breezes Road (North)	L	61.0	59.3	58.8	58.8	59.2
NT		T	56.9	56.8	55.9	56.5	56.7
NR		R	70.5	71.0	70.6	70.8	72.2
EL	Pages Road (East)	L	63.3	62.5	62.6	62.8	63.2
ET		T	63.6	63.1	62.7	63.0	62.7
ER		R	70.5	71.3	71.3	71.3	71.0
SL	Breezes Road (South)	L	52.0	51.6	51.2	50.9	51.0
ST		T	49.6	49.8	49.0	49.4	48.2
SR		R	54.9	53.8	55.5	54.5	54.8
WL	Pages Road (West)	L	48.2	48.1	48.6	47.6	47.7
WT		T	47.3	47.1	46.9	46.3	46.1
WR		R	49.2	50.5	50.9	50.5	51.6
All Movements		All	54.5	55.1	55.6	56.4	58.1
Median Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Breezes Road (North)	L	56.0	53.0	53.0	50.0	53.0
NT		T	51.0	51.0	49.0	49.0	50.0
NR		R	64.0	67.0	67.0	67.0	71.0
EL	Pages Road (East)	L	58.0	56.0	59.0	58.0	59.0
ET		T	58.0	58.0	57.0	58.0	56.0
ER		R	67.0	67.0	68.0	68.0	67.0
SL	Breezes Road (South)	L	48.0	47.0	46.0	45.0	45.0
ST		T	46.0	46.0	44.0	45.0	42.0
SR		R	50.0	47.0	51.0	49.0	50.0
WL	Pages Road (West)	L	43.0	42.0	43.0	41.0	40.0
WT		T	42.0	41.0	41.0	40.0	39.0
WR		R	45.0	46.0	46.0	46.0	47.0
All Movements		All	52.0	52.0	53.0	53.0	55.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Breezes Road (North)	L	46.0	46.0	46.0	46.0	46.0
NT		T	43.0	43.0	43.0	43.0	43.0
NR		R	51.0	52.0	51.0	51.0	52.0
EL	Pages Road (East)	L	51.0	51.0	51.0	51.0	51.0
ET		T	51.0	51.0	51.0	51.0	51.0
ER		R	56.0	55.0	55.0	55.0	55.0
SL	Breezes Road (South)	L	38.0	38.0	38.0	38.0	38.0
ST		T	34.0	34.0	34.0	34.0	34.0
SR		R	40.0	40.0	41.0	40.0	41.0
WL	Pages Road (West)	L	37.0	37.0	37.0	37.0	37.0
WT		T	35.0	35.0	35.0	35.0	35.0
WR		R	39.0	39.0	39.0	39.0	39.0
All Movements		All	36.0	37.0	37.0	37.0	38.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Breezes Road (North)	L	81.0	79.0	79.0	80.0	80.0
NT		T	76.0	77.0	75.0	77.0	77.0
NR		R	92.7	92.0	91.0	92.0	93.0
EL	Pages Road (East)	L	80.0	80.0	79.0	79.0	81.0
ET		T	82.0	81.0	80.0	81.0	80.0
ER		R	87.0	89.0	89.0	88.0	89.0
SL	Breezes Road (South)	L	71.0	69.0	69.0	70.0	70.0
ST		T	70.0	70.0	69.0	70.0	69.0
SR		R	74.0	73.0	76.0	74.0	75.0
WL	Pages Road (West)	L	65.0	65.0	65.0	64.0	65.0
WT		T	64.0	65.0	64.0	64.0	64.0
WR		R	63.0	68.0	67.0	67.0	69.0
All Movements		All	73.0	74.0	74.0	76.0	78.0

A4.6 Full Queue Length Analysis Results

Method 1							
Existing Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Breezes Road (North)	TL	1.3	1.4	1.5	1.7	1.8
N2		R	1.1	1.1	1.2	1.6	2.4
E1	Pages Road (East)	TL	1.7	1.9	2.3	2.7	3.2
E2		R	1.1	1.2	1.2	1.3	1.5
S1	Breezes Road (South)	L	1.2	1.2	1.3	1.4	1.6
S2		T	1.8	2.3	2.8	3.3	3.9
S3		R	1.1	1.1	1.1	1.2	1.3
W1	Pages Road (West)	TL	1.7	2.0	2.4	2.8	4.9
W2		R	1.0	1.1	1.1	1.2	1.3
Maximum Queue Length (vehicles)							
Queue	Approach		**75**	**100**	**125**	**150**	**175**
N1	Breezes Road (North)	TL	1.7	1.9	2.3	2.7	3.2
N2		R	1.2	1.3	1.6	2.3	3.6
E1	Pages Road (East)	TL	2.8	3.5	4.6	5.5	6.8
E2		R	1.2	1.4	1.6	2.0	2.3
S1	Breezes Road (South)	L	1.5	1.6	1.9	2.3	2.8
S2		T	3.2	4.5	5.4	6.6	7.7
S3		R	1.2	1.2	1.4	1.4	1.7
W1	Pages Road (West)	TL	3.0	3.8	4.7	6.0	10.0
W2		R	1.1	1.2	1.3	1.5	1.8
Changed Rule							
Average Queue Length (vehicles)							
Queue	Approach		**75**	**100**	**125**	**150**	**175**
N1	Breezes Road (North)	TL	1.3	1.4	1.5	1.6	2.9
N2		R	1.1	1.1	1.3	1.7	4.1
E1	Pages Road (East)	TL	1.7	1.9	2.3	2.7	3.2
E2		R	1.1	1.2	1.2	1.6	2.6
S1	Breezes Road (South)	L	1.2	1.3	1.4	1.4	1.5
S2		T	1.8	2.3	2.8	3.2	3.6
S3		R	1.1	1.1	1.1	1.2	1.3
W1	Pages Road (West)	TL	1.7	2.0	2.3	2.6	3.2
W2		R	1.0	1.1	1.1	1.2	1.4
Maximum Queue Length (vehicles)							
Queue	Approach		**75**	**100**	**125**	**150**	**175**
N1	Breezes Road (North)	TL	1.7	1.9	2.3	2.6	4.8
N2		R	1.3	1.3	1.6	2.5	5.2
E1	Pages Road (East)	TL	2.8	3.5	4.6	5.3	6.7
E2		R	1.2	1.5	1.7	2.5	3.9
S1	Breezes Road (South)	L	1.5	1.6	1.8	2.2	2.3
S2		T	3.2	4.4	5.4	6.5	7.4
S3		R	1.2	1.2	1.4	1.4	1.7
W1	Pages Road (West)	TL	2.9	3.7	4.5	5.2	6.5
W2		R	1.1	1.2	1.3	1.5	1.9

Method 2							
Existing Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Breezes Road (North)	TL	1.4	1.4	1.3	1.3	1.2
N2		R	1.1	1.1	1.2	1.4	1.7
E1	Pages Road (East)	TL	2.1	1.9	1.8	1.7	1.6
E2		R	1.0	1.2	1.3	1.4	1.7
S1	Breezes Road (South)	L	1.2	1.2	1.2	1.2	1.2
S2		T	2.4	2.3	2.1	2.0	1.7
S3		R	1.0	1.1	1.2	1.3	1.5
W1	Pages Road (West)	TL	2.2	2.0	1.9	1.8	1.6
W2		R	1.0	1.1	1.1	1.2	1.4
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Breezes Road (North)	TL	2.1	1.9	1.8	1.8	1.5
N2		R	1.1	1.3	1.7	2.1	3.0
E1	Pages Road (East)	TL	3.8	3.5	3.1	2.9	2.5
E2		R	1.1	1.4	1.8	2.2	3.1
S1	Breezes Road (South)	L	1.7	1.6	1.6	1.5	1.4
S2		T	4.7	4.5	3.8	3.5	2.7
S3		R	1.1	1.2	1.6	1.7	2.3
W1	Pages Road (West)	TL	4.1	3.8	3.5	3.1	2.6
W2		R	1.1	1.2	1.3	1.6	2.1
Changed Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Breezes Road (North)	TL	1.4	1.4	1.3	1.3	1.2
N2		R	1.0	1.1	1.2	1.4	1.7
E1	Pages Road (East)	TL	2.1	1.9	1.8	1.7	1.5
E2		R	1.1	1.2	1.3	1.4	1.8
S1	Breezes Road (South)	L	1.3	1.3	1.2	1.2	1.2
S2		T	2.4	2.3	2.1	2.0	1.7
S3		R	1.0	1.1	1.2	1.3	1.5
W1	Pages Road (West)	TL	2.2	2.0	1.9	1.8	1.6
W2		R	1.0	1.1	1.1	1.2	1.4
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Breezes Road (North)	TL	2.1	1.9	1.8	1.7	1.5
N2		R	1.1	1.3	1.7	2.2	3.0
E1	Pages Road (East)	TL	3.8	3.5	3.1	2.9	2.5
E2		R	1.1	1.5	1.9	2.3	3.1
S1	Breezes Road (South)	L	1.7	1.6	1.6	1.5	1.4
S2		T	4.7	4.4	3.8	3.5	2.7
S3		R	1.1	1.2	1.6	1.7	2.3
W1	Pages Road (West)	TL	4.1	3.7	3.3	3.0	2.5
W2		R	1.1	1.2	1.4	1.6	2.1

APPENDIX A5

Intersection 3 – Marshland Road/The Palms

Full Data

Table of Contents

A5.1 Approach Photos

Figure A5.1.1 - Marshland Road North Approach

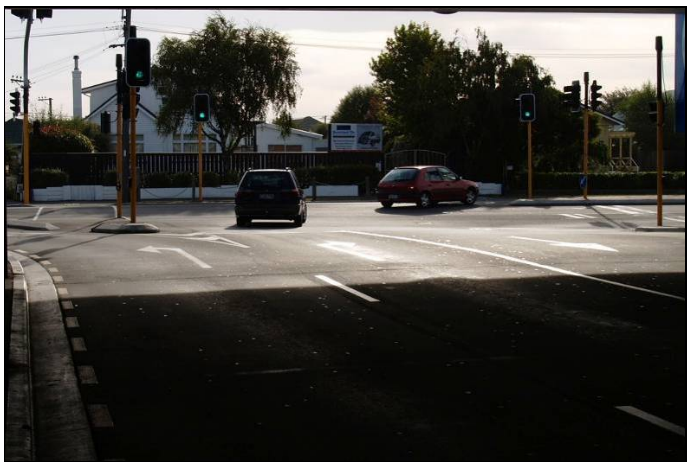


Figure A5.1.2 - The Palms East Approach

Figure A5.1.3 - Marshland Road South Approach

A5.2 Surveyed Traffic Volume Data

Intersection 3: Marshland Road/The Palms

Survey Date Tuesday, 7 November 2006

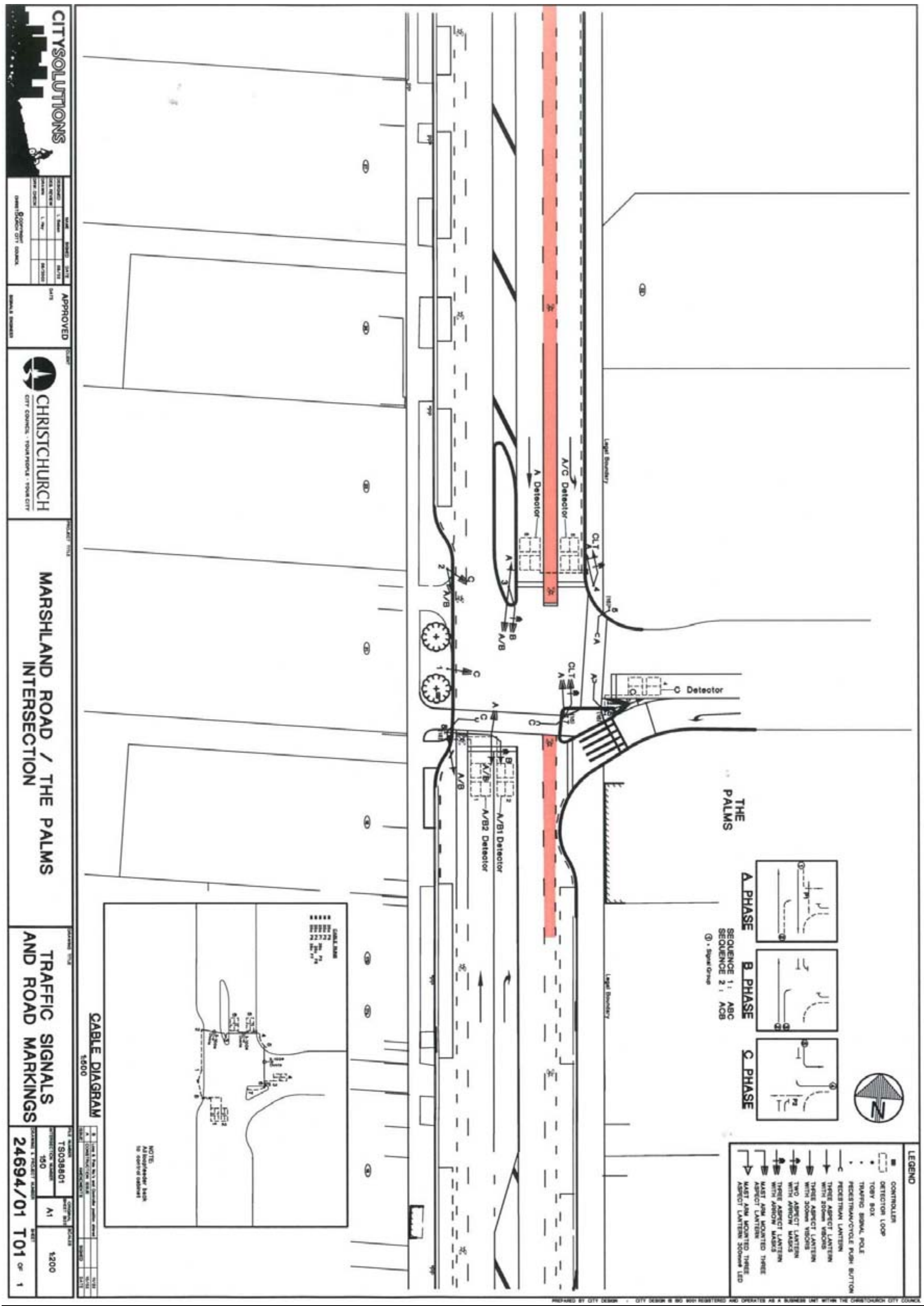
Light Vehicles			The Palms		Marshland (North)		Marshland (South)		TOTAL
			L	R	T	L	T	R	
2:30	-	2:45	49	27	41	47	77	62	303
2:45	-	3:00	47	22	78	46	73	45	311
3:00	-	3:15	49	23	63	69	64	37	305
3:15	-	3:30	47	40	66	47	72	45	317
3:30	-	3:45	52	36	58	50	76	53	325
3:45	-	4:00	38	24	51	54	83	49	299

Heavy Vehicles			The Palms		Marshland (North)		Marshland (South)		TOTAL
			L	R	T	L	T	R	
2:30	-	2:45	2	0	3	0	5	0	10
2:45	-	3:00	3	0	3	1	3	2	12
3:00	-	3:15	2	0	1	0	1	0	4
3:15	-	3:30	1	1	1	0	2	0	5
3:30	-	3:45	2	0	1	0	3	1	7
3:45	-	4:00	0	1	3	0	2	1	7

Total (2:30pm to 4:00pm)	The Palms		Marshland (North)		Marshland (South)	
	L	R	T	L	T	R
Light	282	172	357	313	445	291
Heavy	10	2	12	1	16	4

Peak Hour (2:45pm to 3:45pm)	The Palms		Marshland (North)		Marshland (South)	
	L	R	T	L	T	R
Light	195	121	265	212	285	180
Heavy	8	1	6	1	9	3

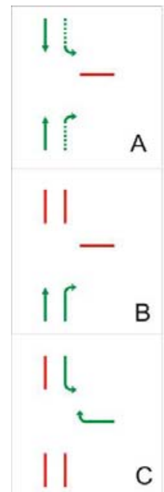
A5.3 Traffic Signal Plan



A5.4 Observed and Modelled Signal Timings

Intersection 3 Marshland Road/The Palms (SCATS ID = 150)

Traffic Count Day		Tuesday 7 November, 2006		
Observed Signal Day		Tuesday 19 September, 2006		
Observed Time Period		2:30pm to 4:00pm		
Observed Phase Timings				
Phase	Count	Minimum (s)	Maximum (s)	Average (s)
A	68	26	93	52
B	44	10	26	16
C	67	13	26	18
Cycle	-	-	-	86
Modelled Phase Timings				
A	-	-	-	50
B	-	-	-	15
C	-	-	-	10
Cycle	-	-	-	75



A5.5 Results Summary

A5.5.1 Journey Times Method 1

Figure 5.5.1 to Figure 5.5.3 present journey time comparisons for the right and left turn movements off Marshland Road and for the average journey time for all movements through the intersection.

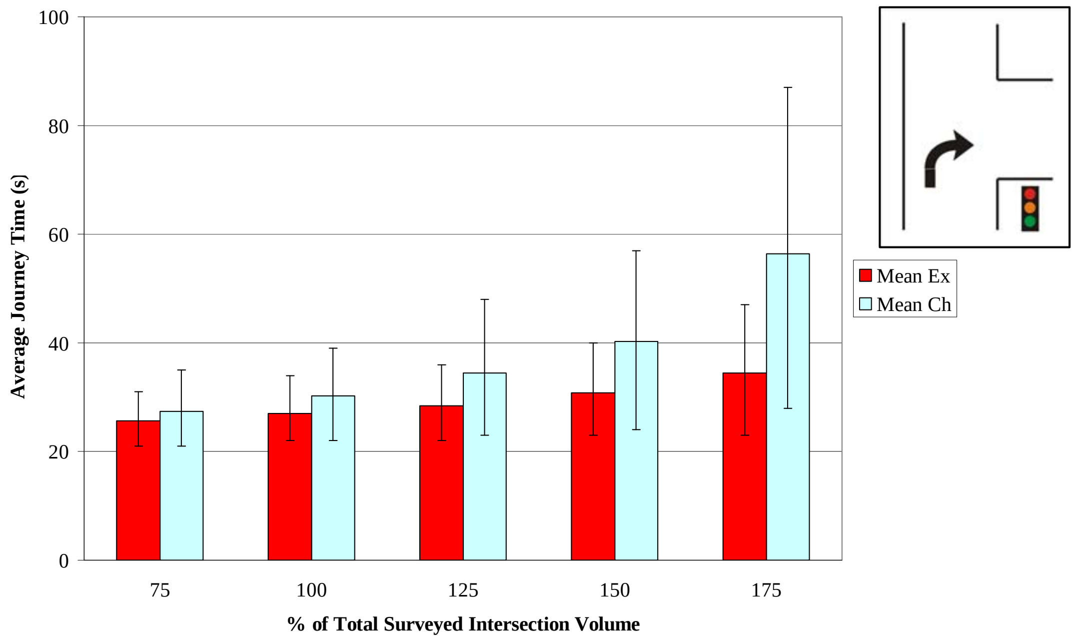


Figure 5.5.1 - Intersection 3, M1, Marshland Road Right Turn Journey Time Comparison

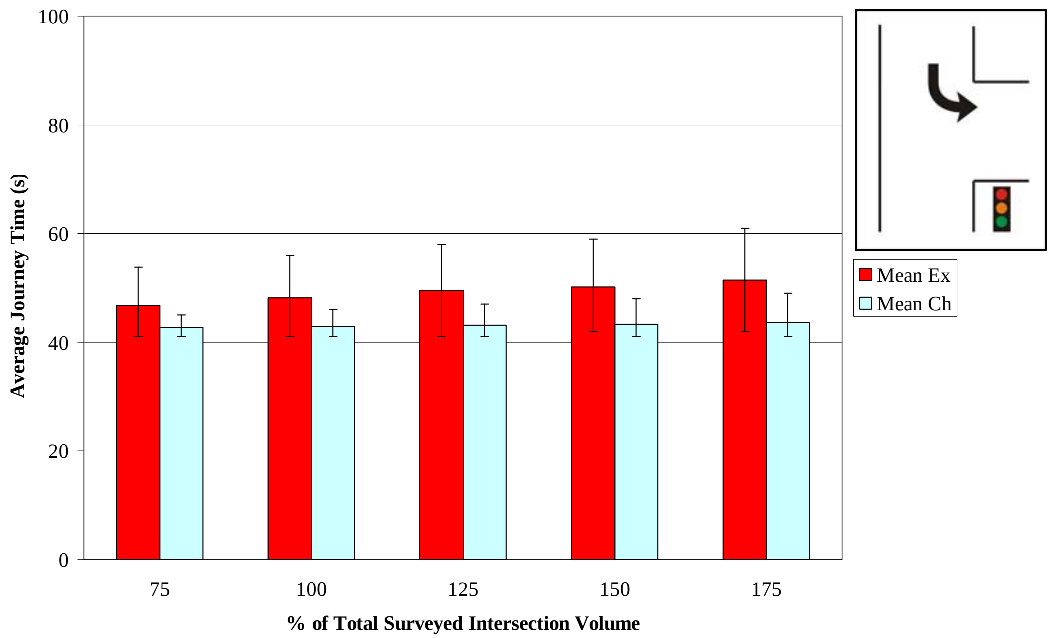


Figure 5.5.2 - Intersection 3, M1, Marshland Road Left Turn Journey Time Comparison

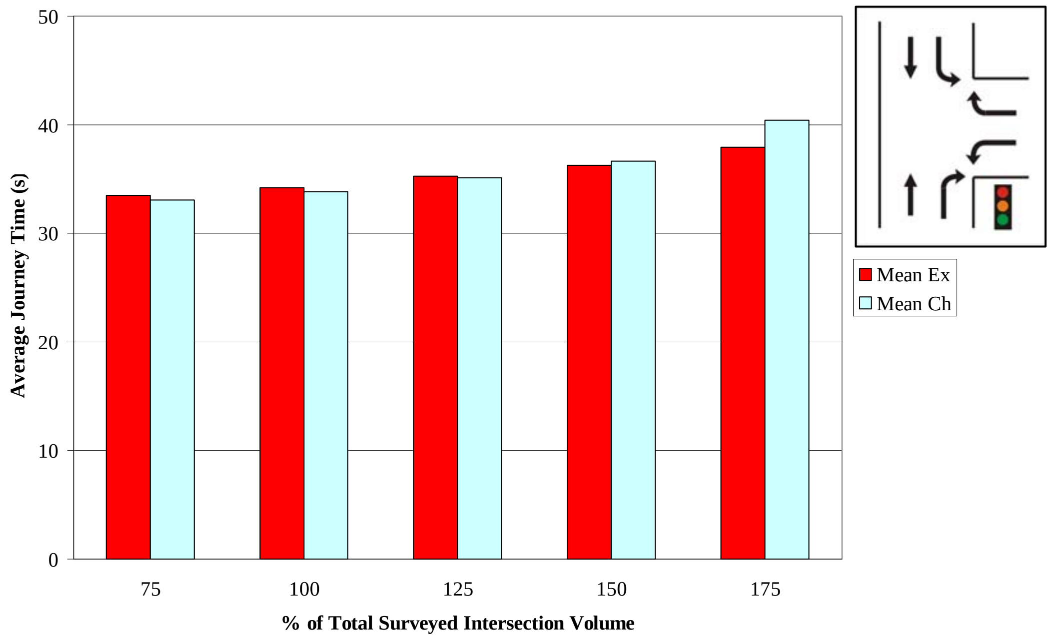


Figure 5.5.3 - Intersection 3, M1, Total Intersection Journey Time Comparison

A5.5.2 Journey Times Method 2

Figure 5.5.4 to Figure 5.5.6 present journey time comparisons for the right and left turn movements off Marshland Road and for the average journey time for all movements through the intersection.

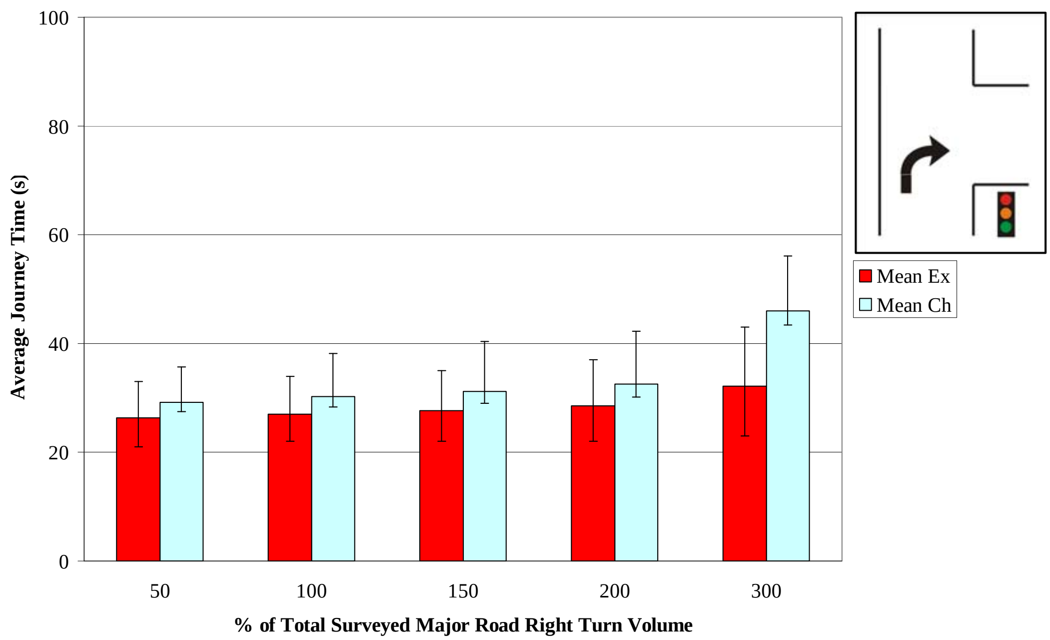


Figure 5.5.4 - Intersection 3, M2, Marshland Road Right Turn Journey Time Comparison

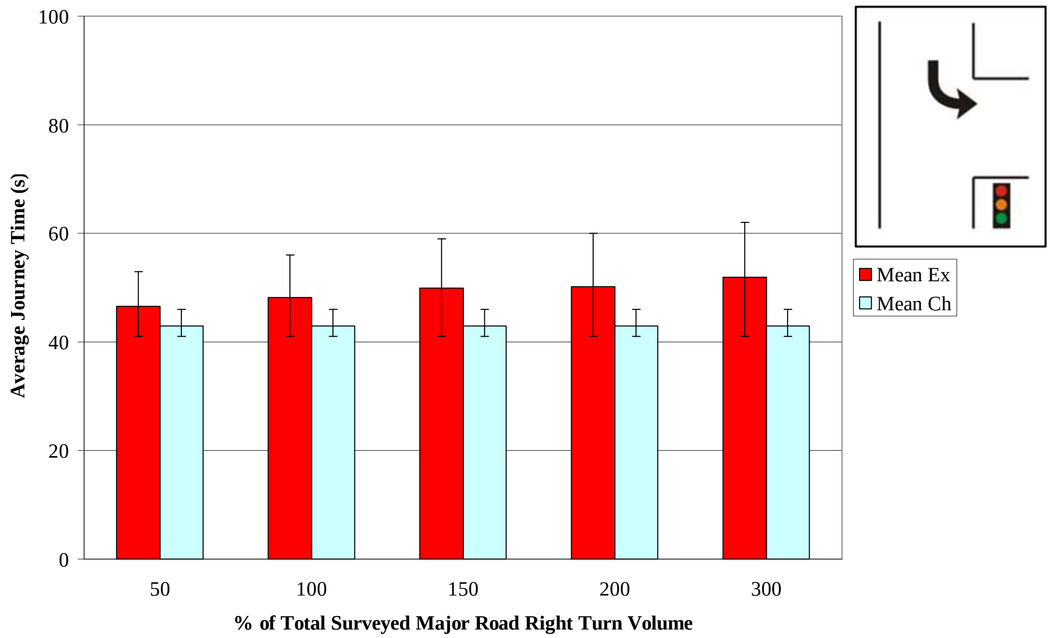


Figure 5.5.5 - Intersection 3, M2, Marshland Road Left Turn Journey Time Comparison

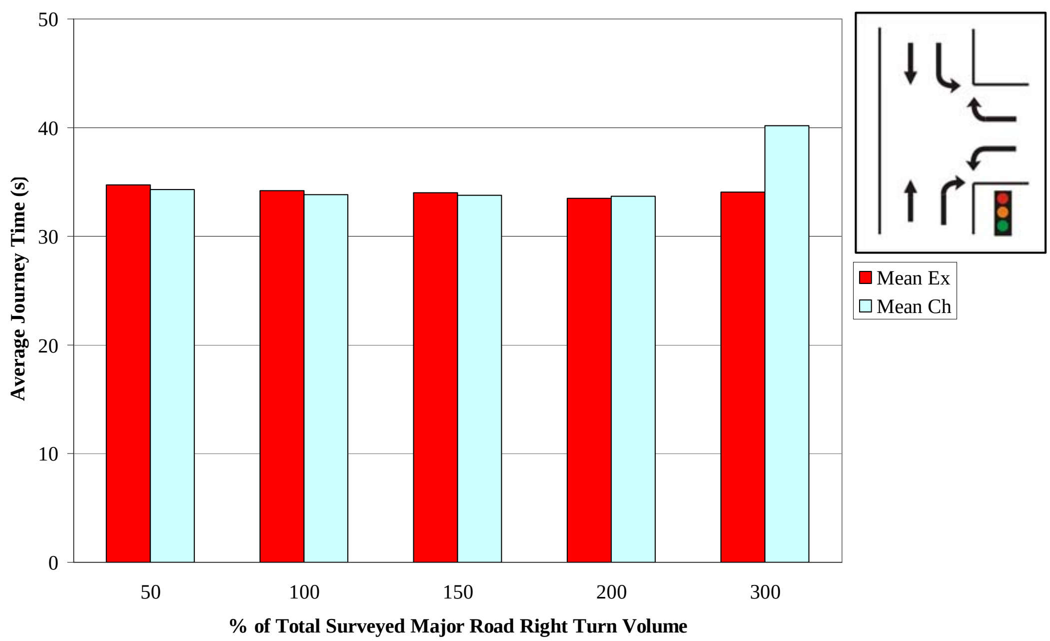


Figure 5.5.6 - Intersection 3, M2, Total Intersection Journey Time Comparison

Table 5.5.1 summarises the average journey time for all movements for each volume scenario.

Table 5.5.1 - Intersection 3, M2, Average Journey Time Comparison

Approach	Mvt	Average Journey Time (seconds/vehicle) for Various % Scenarios									
		50%		100%		150%		200%		300%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Marshland Road (North)	L	47	43	48	43	50	43	50	43	52	43
	T	52	52	52	52	52	52	51	51	51	51
The Palms (East)	L	20	20	20	20	19	19	19	19	18	18
	R	40	40	40	40	41	41	41	41	41	41
Marshland Road (South)	T	23	23	23	23	22	22	22	22	22	25
	R	26	29	27	30	28	31	29	32	32	46
Total	All	35	34	34	34	34	34	33	34	34	40

As expected, the right turn journey time increases and the left turn journey time decreases as a result of the rule change to nearside priority under all volume scenarios. Across all movements there is little difference in the average journey time for the first four scenarios however for the 300% scenario the existing rule results in an average journey time 6 seconds shorter than the changed rule.

Table 5.5.2 summarises the changes in the right and left turn journey times off Marshland Road.

Table 5.5.2 - Intersection 3, M2, Right and Left Turn Journey Time Changes

Movement	Change in Journey Time (seconds/vehicle) for Various % Scenarios				
	75%	100%	125%	150%	175%
Marshland Road Right Turn	3	3	3	3	14
Marshland Road Left Turn	-4	-5	-7	-7	-9

Table 5.5.2 shows that the right turn journey time increases by more than the corresponding reduction in left turn journey time. The difference becomes larger as the proportion of right turning vehicles is increased.

A5.5.3 Queue Lengths Method 1

Figure 5.5.7 to Figure 5.5.9 present queue length comparisons for the right and left turns off Marshland Road, and also for the longest queue in any lane on the approach from The Palms.

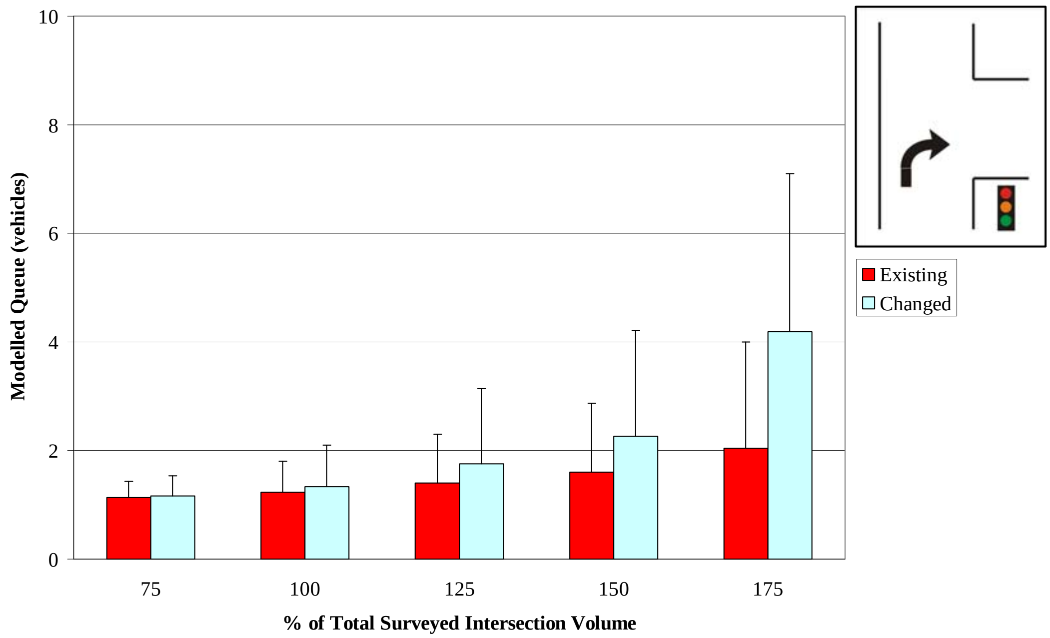


Figure 5.5.7 - Intersection 3, M1, Marshland Road Right Turn Queue Comparison

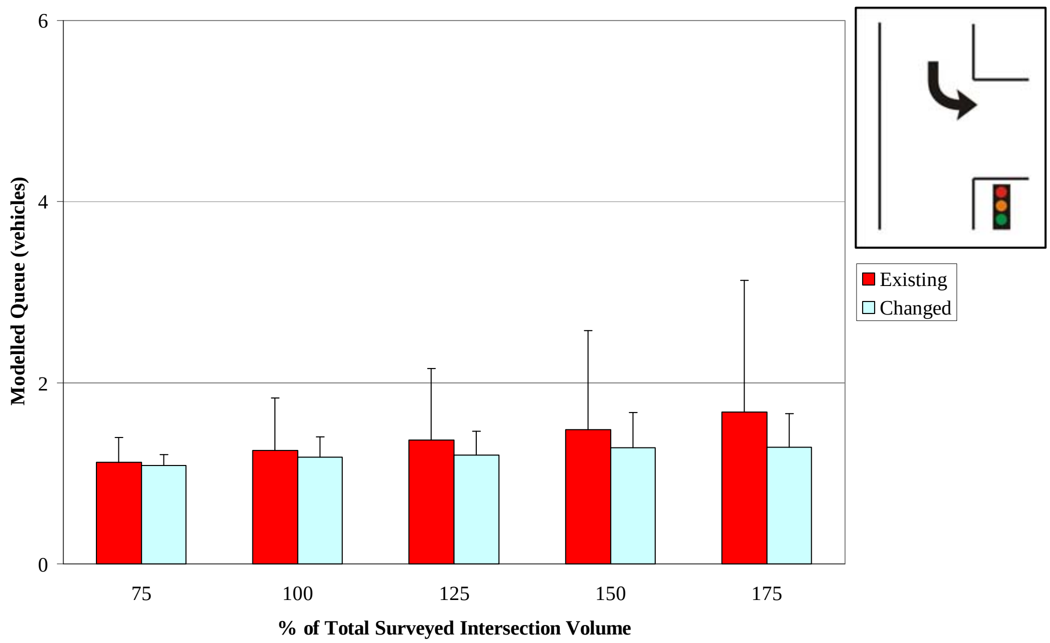


Figure 5.5.8 - Intersection 3, M1, Marshland Road Left Turn Queue Comparison

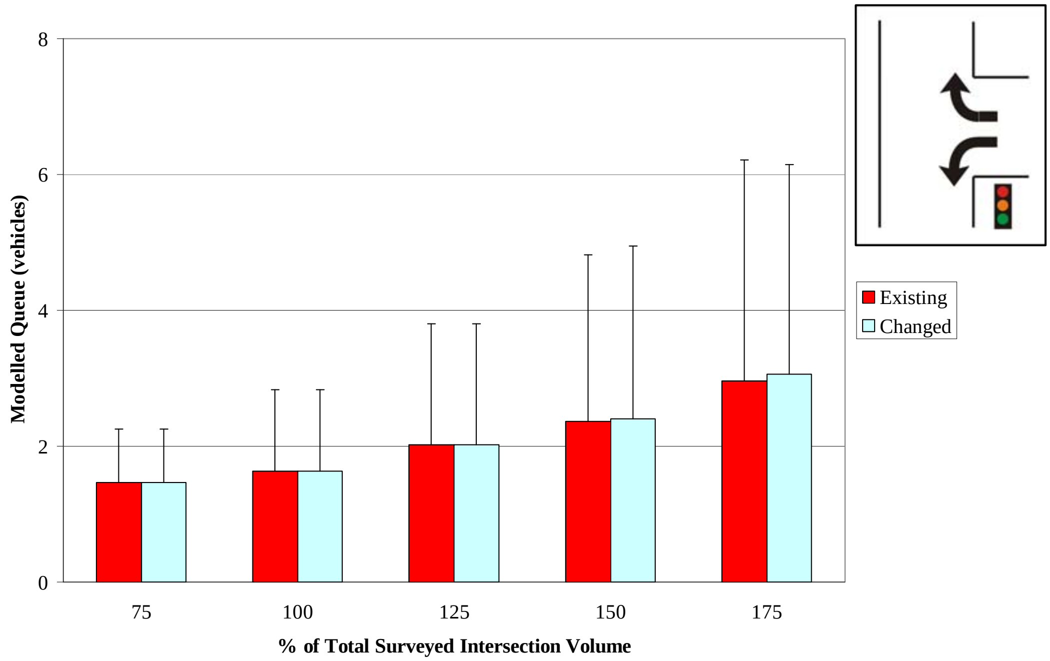


Figure 5.5.9 - Intersection 3, M1, The Palms Queue Comparison (Longest Queue in Any Lane)

A5.5.4 Queue Lengths Method 2

Figure 5.5.10 to Figure 5.5.12 present queue length comparisons for right and left turns off Marshland Road, and also for the longest queue in any lane on the approach from The Palms.

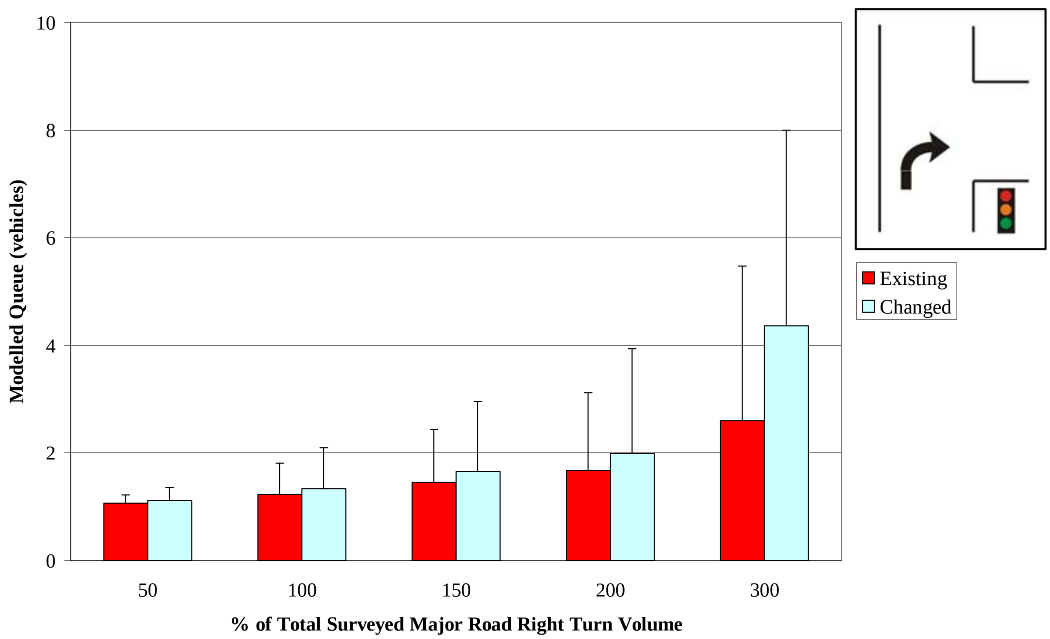


Figure 5.5.10 - Intersection 3, M2, Marshland Road Right Turn Queue Comparison

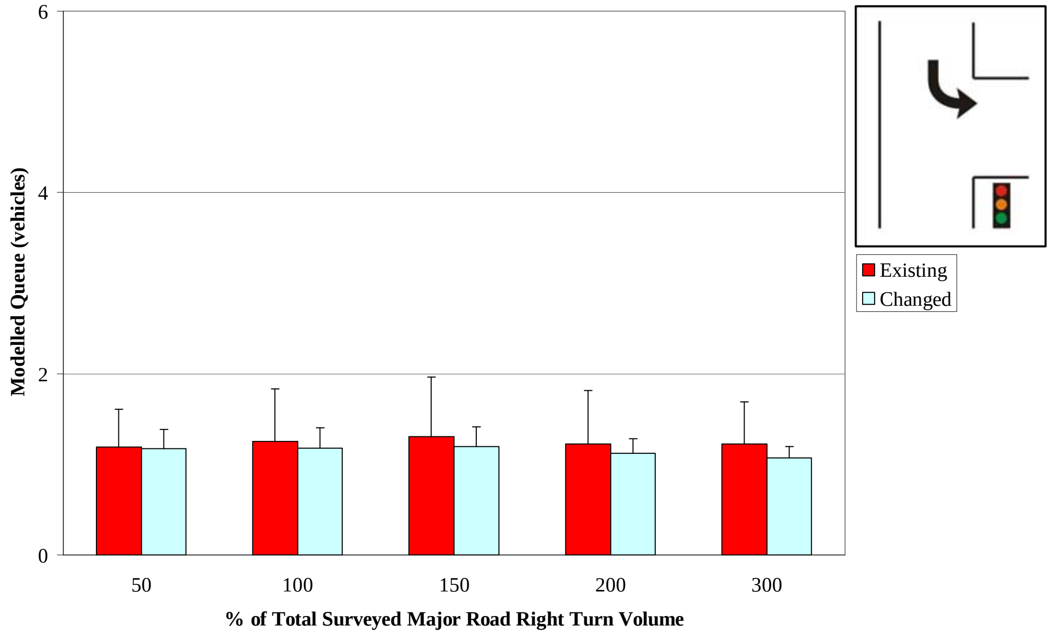


Figure 5.5.11 - Intersection 3, M2, Marshland Road Left Turn Queue Comparison

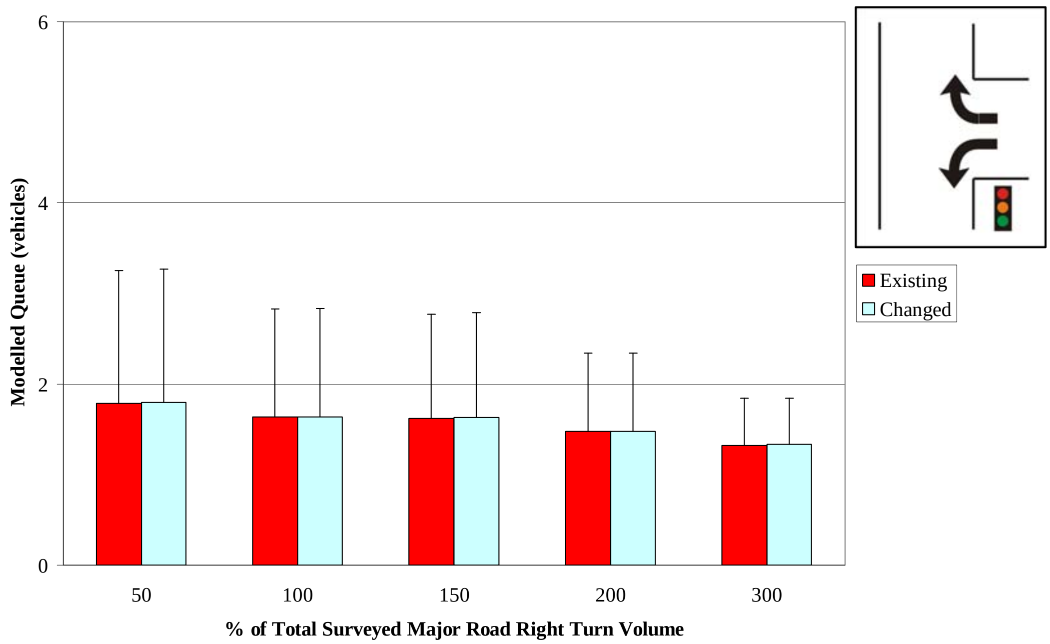


Figure 5.5.12 - Intersection 3, M2, The Palms Queue Comparison (Longest Queue in Any Lane)

Table 5.5.3 summarises the average queue lengths for various volume scenarios.

Table 5.5.3 - Intersection 3, M2, Average Queue Comparison

Approach	Mvt	Average Queue Length (vehicles) for Various % Scenarios									
		50%		100%		150%		200%		300%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Marshland Road (North)	L	1.2	1.2	1.3	1.2	1.3	1.2	1.2	1.1	1.2	1.1
	T	1.7	1.8	1.7	1.6	1.6	1.6	1.4	1.4	1.4	1.4
The Palms (East)	L	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.1
	R	1.8	1.8	1.6	1.6	1.6	1.6	1.5	1.5	1.3	1.3
Marshland Road (South)	T	1.4	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.2	2.0
	R	1.1	1.1	1.2	1.3	1.5	1.7	1.7	2.0	2.6	4.4

Overall the queue comparison shows a similar pattern as the journey time comparison where the right turn queue increases under the rule change to nearside priority and the left turn queue decreases. The increase in the right turn queue is however larger than the corresponding decrease for the left turn. There is little difference on the approach from The Palms which is expected given the signal timings have not changed.

A5.6 Full Journey Time Analysis Results

Method 1 Existing Rule							
Mean Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Marshland Road (North)	L	46.8	48.1	49.6	50.2	51.4
NT		T	51.0	51.9	52.3	52.7	53.8
EL	The Palms (East)	L	18.6	19.6	21.5	23.9	26.5
ER		R	41.2	39.8	42.2	42.7	45.1
ST	Marshland Road (South)	T	22.2	22.5	22.6	22.8	23.0
SR		R	25.7	27.0	28.4	30.8	34.4
All Movements		All	33.5	34.2	35.3	36.3	37.9
Median Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Marshland Road (North)	L	44.0	45.0	47.0	48.0	49.0
NT		T	44.0	44.0	44.0	45.0	47.0
EL	The Palms (East)	L	17.0	17.0	19.0	21.0	23.0
ER		R	40.0	39.0	41.0	41.0	45.0
ST	Marshland Road (South)	T	19.0	19.0	19.0	19.0	19.0
SR		R	23.0	25.0	26.0	28.0	31.0
All Movements		All	27.0	29.0	32.0	34.0	37.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Marshland Road (North)	L	41.0	41.0	41.0	42.0	42.0
NT		T	42.0	42.0	42.0	42.0	42.0
EL	The Palms (East)	L	17.0	17.0	17.0	17.0	17.0
ER		R	11.0	11.0	12.0	13.0	14.0
ST	Marshland Road (South)	T	19.0	19.0	19.0	19.0	19.0
SR		R	21.0	22.0	22.0	23.0	23.0
All Movements		All	19.0	19.0	19.0	19.0	19.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Marshland Road (North)	L	53.9	56.0	58.0	59.0	61.0
NT		T	68.0	69.0	70.0	70.0	72.0
EL	The Palms (East)	L	21.0	23.0	28.0	33.0	38.0
ER		R	71.0	70.0	72.0	72.0	75.0
ST	Marshland Road (South)	T	29.0	31.0	31.0	31.0	32.0
SR		R	31.0	34.0	36.0	40.0	47.0
All Movements		All	50.0	51.0	53.0	54.0	57.0

Method 1 Changed Rule							
Mean Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Marshland Road (North)	L	42.7	42.9	43.2	43.3	43.6
NT		T	51.0	51.7	51.9	52.2	52.6
EL	The Palms (East)	L	18.6	19.6	21.7	24.4	27.9
ER		R	41.2	39.8	42.2	42.7	45.9
ST	Marshland Road (South)	T	22.2	22.5	22.7	23.0	24.3
SR		R	27.4	30.3	34.4	40.2	56.4
All Movements		All	33.1	33.8	35.1	36.7	40.4
Median Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Marshland Road (North)	L	41.0	41.0	41.0	41.0	41.0
NT		T	44.0	44.0	44.0	45.0	45.0
EL	The Palms (East)	L	17.0	17.0	19.0	21.0	24.0
ER		R	40.0	39.0	41.0	41.0	46.0
ST	Marshland Road (South)	T	19.0	19.0	19.0	19.0	19.0
SR		R	25.0	27.0	31.0	36.0	50.0
All Movements		All	29.0	32.0	35.0	38.0	41.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Marshland Road (North)	L	41.0	41.0	41.0	41.0	41.0
NT		T	42.0	42.0	42.0	42.0	42.0
EL	The Palms (East)	L	17.0	17.0	17.0	17.0	17.0
ER		R	11.0	11.0	12.0	13.0	15.0
ST	Marshland Road (South)	T	19.0	19.0	19.0	19.0	19.0
SR		R	21.0	22.0	23.0	24.0	28.0
All Movements		All	19.0	19.0	19.0	19.0	19.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Marshland Road (North)	L	45.0	46.0	47.0	48.0	49.0
NT		T	68.0	69.0	69.0	70.0	70.0
EL	The Palms (East)	L	21.0	23.0	28.0	34.0	39.0
ER		R	71.0	70.0	73.0	72.0	75.0
ST	Marshland Road (South)	T	29.0	31.0	31.0	32.0	34.0
SR		R	35.0	39.0	48.0	57.0	87.0
All Movements		All	46.0	47.2	50.0	53.0	60.0

Method 2 Existing Rule							
Mean Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Marshland Road (North)	L	46.6	48.1	49.9	50.2	51.9
NT		T	51.9	51.9	51.7	51.2	50.7
EL	The Palms (East)	L	20.4	19.6	19.5	18.8	18.3
ER		R	40.1	39.8	41.5	41.4	40.9
ST	Marshland Road (South)	T	22.5	22.5	22.4	22.1	22.1
SR		R	26.3	27.0	27.7	28.6	32.2
All Movements		All	34.7	34.2	34.0	33.5	34.1
Median Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Marshland Road (North)	L	45.0	45.0	47.0	48.0	49.0
NT		T	44.0	44.0	44.0	44.0	44.0
EL	The Palms (East)	L	18.0	17.0	17.0	17.0	17.0
ER		R	38.0	39.0	40.0	40.0	41.0
ST	Marshland Road (South)	T	19.0	19.0	19.0	19.0	19.0
SR		R	24.0	25.0	25.0	26.0	29.0
All Movements		All	33.0	29.0	28.0	28.0	30.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Marshland Road (North)	L	41.0	41.0	41.0	41.0	41.0
NT		T	42.0	42.0	42.0	42.0	42.0
EL	The Palms (East)	L	17.0	17.0	17.0	17.0	17.0
ER		R	11.0	11.0	12.0	11.0	10.0
ST	Marshland Road (South)	T	19.0	19.0	19.0	19.0	19.0
SR		R	21.0	22.0	22.0	22.0	23.0
All Movements		All	19.0	19.0	19.0	19.0	19.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Marshland Road (North)	L	53.0	56.0	59.0	60.0	62.0
NT		T	69.0	69.0	69.0	68.0	67.0
EL	The Palms (East)	L	25.0	23.0	23.0	22.0	21.0
ER		R	70.0	70.0	71.0	72.0	71.0
ST	Marshland Road (South)	T	31.0	31.0	30.0	29.0	29.0
SR		R	33.0	34.0	35.0	37.0	43.0
All Movements		All	51.0	51.0	51.0	50.0	50.0

Method 2 Changed Rule							
Mean Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Marshland Road (North)	L	43.0	42.9	42.9	42.9	42.9
NT		T	51.9	51.7	51.5	51.0	50.9
EL	The Palms (East)	L	20.4	19.6	19.5	18.8	18.4
ER		R	40.3	39.8	41.5	41.4	41.0
ST	Marshland Road (South)	T	22.5	22.5	22.4	22.2	25.5
SR		R	29.2	30.3	31.2	32.5	46.0
All Movements		All	34.3	33.8	33.8	33.7	40.1
Median Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Marshland Road (North)	L	41.0	41.0	41.0	41.0	41.0
NT		T	44.0	44.0	44.0	44.0	44.0
EL	The Palms (East)	L	18.0	17.0	17.0	17.0	17.0
ER		R	39.0	39.0	41.0	40.0	41.0
ST	Marshland Road (South)	T	19.0	19.0	19.0	19.0	19.0
SR		R	26.0	27.0	28.0	30.0	40.0
All Movements		All	34.0	32.0	31.0	31.0	40.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Marshland Road (North)	L	41.0	41.0	41.0	41.0	41.0
NT		T	42.0	42.0	42.0	42.0	42.0
EL	The Palms (East)	L	17.0	17.0	17.0	17.0	17.0
ER		R	11.0	11.0	12.0	11.0	10.0
ST	Marshland Road (South)	T	19.0	19.0	19.0	19.0	19.0
SR		R	21.0	22.0	22.0	23.0	25.0
All Movements		All	19.0	19.0	19.0	19.0	19.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Marshland Road (North)	L	46.0	46.0	46.0	46.0	46.0
NT		T	69.0	69.0	69.0	68.0	68.0
EL	The Palms (East)	L	25.0	23.0	23.0	22.0	21.0
ER		R	70.0	70.0	71.0	72.0	71.0
ST	Marshland Road (South)	T	31.0	31.0	30.0	29.0	36.0
SR		R	38.0	39.0	41.3	43.0	70.0
All Movements		All	49.0	47.2	47.0	47.0	61.0

A5.7 Full Queue Length Analysis Results

Method 1							
Existing Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Marshland Road (North)	L	1.1	1.3	1.4	1.5	1.7
N2		T	1.4	1.7	1.9	2.2	2.5
EL1	The Palms (East)	L	1.0	1.1	1.2	1.4	1.6
E1		R	1.5	1.6	2.0	2.4	3.0
S1	Marshland Road (South)	T	1.2	1.4	1.5	1.6	1.8
S2		R	1.1	1.2	1.4	1.6	2.0
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Marshland Road (North)	L	1.4	1.8	2.2	2.6	3.1
N2		T	2.1	2.7	3.4	3.8	4.8
EL1	The Palms (East)	L	1.2	1.4	1.8	2.3	2.7
E1		R	2.2	2.8	3.8	4.8	6.2
S1	Marshland Road (South)	T	1.6	1.8	2.2	2.4	2.7
S2		R	1.4	1.8	2.3	2.9	4.0
Changed Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Marshland Road (North)	L	1.1	1.2	1.2	1.3	1.3
N2		T	1.4	1.6	1.9	2.1	2.4
EL1	The Palms (East)	L	1.0	1.1	1.3	1.4	1.6
E1		R	1.5	1.6	2.0	2.4	3.1
S1	Marshland Road (South)	T	1.2	1.4	1.5	1.7	2.0
S2		R	1.2	1.3	1.8	2.3	4.2
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Marshland Road (North)	L	1.2	1.4	1.5	1.7	1.7
N2		T	2.1	2.7	3.2	3.7	4.4
EL1	The Palms (East)	L	1.2	1.4	1.9	2.4	3.0
E1		R	2.2	2.8	3.8	4.9	6.1
S1	Marshland Road (South)	T	1.6	1.8	2.2	2.6	3.2
S2		R	1.5	2.1	3.1	4.2	7.1

Method 2							
Existing Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Marshland Road (North)	L	1.2	1.3	1.3	1.2	1.2
N2		T	1.7	1.7	1.6	1.4	1.4
EL1	The Palms (East)	L	1.2	1.1	1.1	1.1	1.0
E1		R	1.8	1.6	1.6	1.5	1.3
S1	Marshland Road (South)	T	1.4	1.4	1.3	1.3	1.2
S2		R	1.1	1.2	1.5	1.7	2.6
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Marshland Road (North)	L	1.6	1.8	2.0	1.8	1.7
N2		T	3.0	2.7	2.5	2.1	1.9
EL1	The Palms (East)	L	1.6	1.4	1.4	1.2	1.2
E1		R	3.3	2.8	2.8	2.3	1.8
S1	Marshland Road (South)	T	1.9	1.8	1.7	1.6	1.4
S2		R	1.2	1.8	2.4	3.1	5.5
Changed Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Marshland Road (North)	L	1.2	1.2	1.2	1.1	1.1
N2		T	1.8	1.6	1.6	1.4	1.4
EL1	The Palms (East)	L	1.2	1.1	1.1	1.1	1.1
E1		R	1.8	1.6	1.6	1.5	1.3
S1	Marshland Road (South)	T	1.4	1.4	1.3	1.3	2.0
S2		R	1.1	1.3	1.7	2.0	4.4
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Marshland Road (North)	L	1.4	1.4	1.4	1.3	1.2
N2		T	3.0	2.7	2.4	2.1	1.9
EL1	The Palms (East)	L	1.6	1.4	1.4	1.2	1.2
E1		R	3.3	2.8	2.8	2.3	1.8
S1	Marshland Road (South)	T	1.9	1.8	1.7	1.6	3.1
S2		R	1.4	2.1	3.0	3.9	8.0

APPENDIX A6

Intersection 4 – Bealey Avenue/Colombo Street

Full Data

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A6.1 Approach Photos

Figure A6.1.1 - Colombo Street South Approach

Figure A6.1.3 - Colombo Street North Approach

Figure A6.1.2 - Bealey Avenue West Approach

Figure A6.1.4 - Bealey Avenue East Approach

A6.2 Surveyed Traffic Volume Data

Intersection 4: Bealey Avenue/Colombo Street

Survey Date Tuesday, 14 November 2006

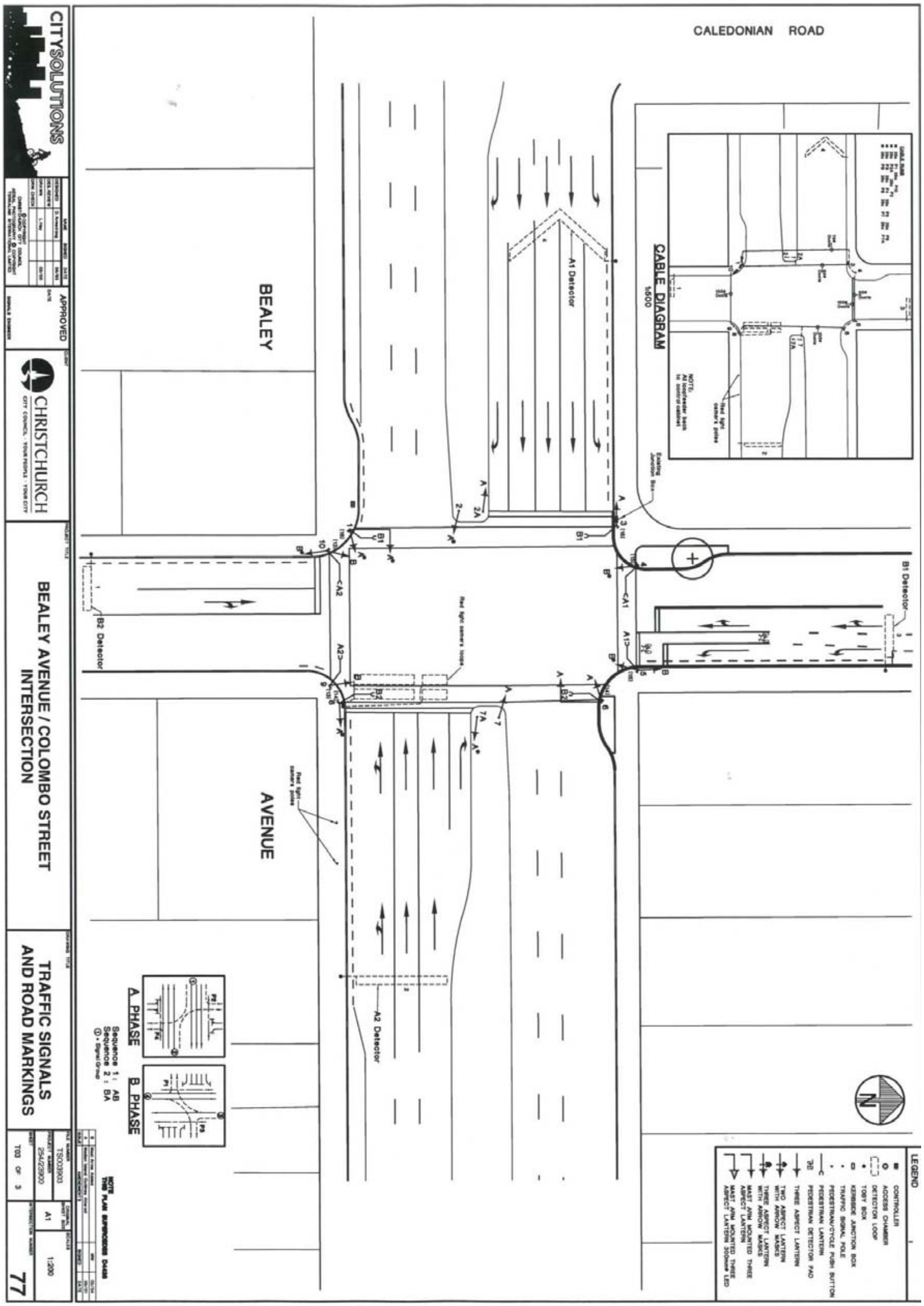
Light Vehicles			Colombo (South)			Bealey (East)			Colombo (North)			Bealey (West)			TOTAL
			L	T	R	L	T	R	L	T	R	L	T	R	
4:30	-	4:45	26	21	8	14	208	33	7	12	10	12	217	18	586
4:45	-	5:00	31	16	13	15	179	19	9	14	11	16	277	22	622
5:00	-	5:15	35	27	14	21	209	40	15	17	7	27	230	25	667
5:15	-	5:30	32	24	14	30	232	47	7	25	0	45	236	30	722
5:30	-	5:45	26	22	10	19	197	37	22	39	10	10	233	30	655
5:45	-	6:00	24	25	9	16	198	36	10	50	10	50	278	20	726

Heavy Vehicles			Colombo (South)			Bealey (East)			Colombo (North)			Bealey (West)			TOTAL
			L	T	R	L	T	R	L	T	R	L	T	R	
4:30	-	4:45	0	1	0	1	6	2	0	1	0	0	6	0	17
4:45	-	5:00	0	1	0	0	6	1	0	2	0	0	5	1	16
5:00	-	5:15	2	2	1	0	7	3	0	4	1	0	3	1	24
5:15	-	5:30	0	2	0	1	13	2	0	1	3	2	6	0	30
5:30	-	5:45	1	3	0	1	11	1	0	5	3	2	6	2	35
5:45	-	6:00	2	1	1	0	8	2	2	10	2	6	3	2	39

Total	Colombo (South)			Bealey (East)			Colombo (North)			Bealey (West)		
(4:30pm - 6:00pm)	L	T	R	L	T	R	L	T	R	L	T	R
Light	174	135	68	115	1,223	212	70	157	48	160	1,471	145
Heavy	5	10	2	3	51	11	2	23	9	10	29	6

Peak Hour	Colombo (South)			Bealey (East)			Colombo (North)			Bealey (West)		
(4:45pm - 5:45pm)	L	T	R	L	T	R	L	T	R	L	T	R
Light	124	89	51	85	817	143	53	95	28	98	976	107
Heavy	3	8	1	2	37	7	0	12	7	4	20	4

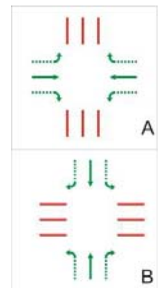
A6.3 Traffic Signal Plan



A6.4 Observed and Modelled Signal Timings

Intersection 4 Bealey Avenue/Colombo Street (SCATS ID = 77)

Traffic Count Day		Tuesday 14 November, 2006		
Observed Signal Day		Thursday 21 November, 2006		
Observed Time Period		4:30pm to 6:30pm		
Observed Phase Timings				
Phase	Count	Minimum (s)	Maximum (s)	Average (s)
A	59	39	85	58
B	59	18	45	34
Cycle	-	-	-	92
Modelled Phase Timings				
A	-	-	-	53
B	-	-	-	27
Cycle	-	-	-	80



A6.5 Results Summary

A6.5.1 Journey Times Method 1

Figure A6.5.1 to Figure A6.5.4 present the average journey times for the four right turn movements at the intersection.

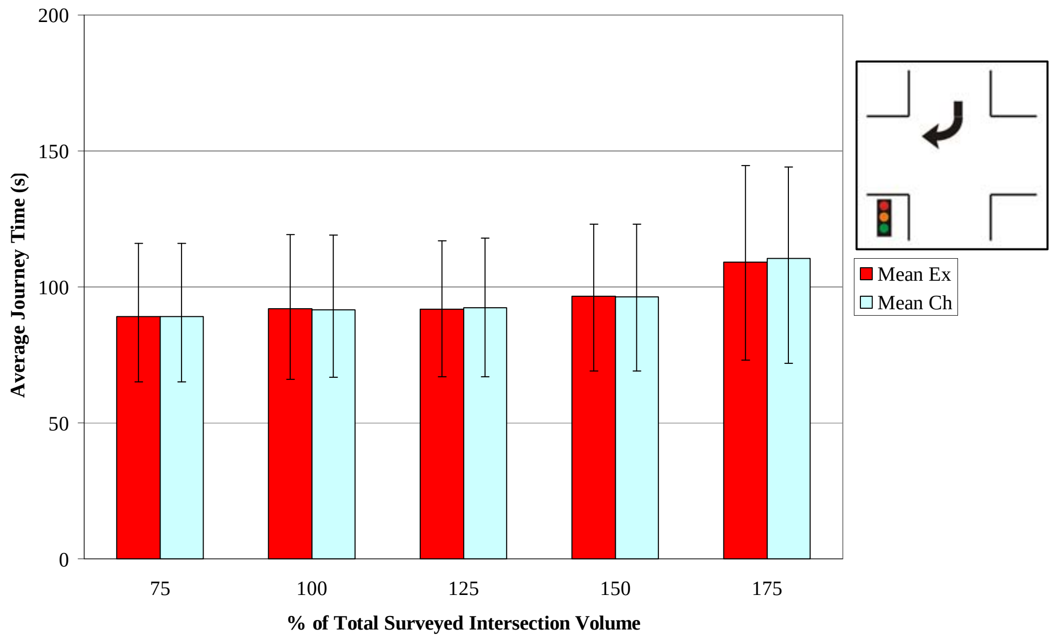


Figure A6.5.1 - Intersection 4, M1, Colombo Street (North) Right Turn Journey Time Comparison

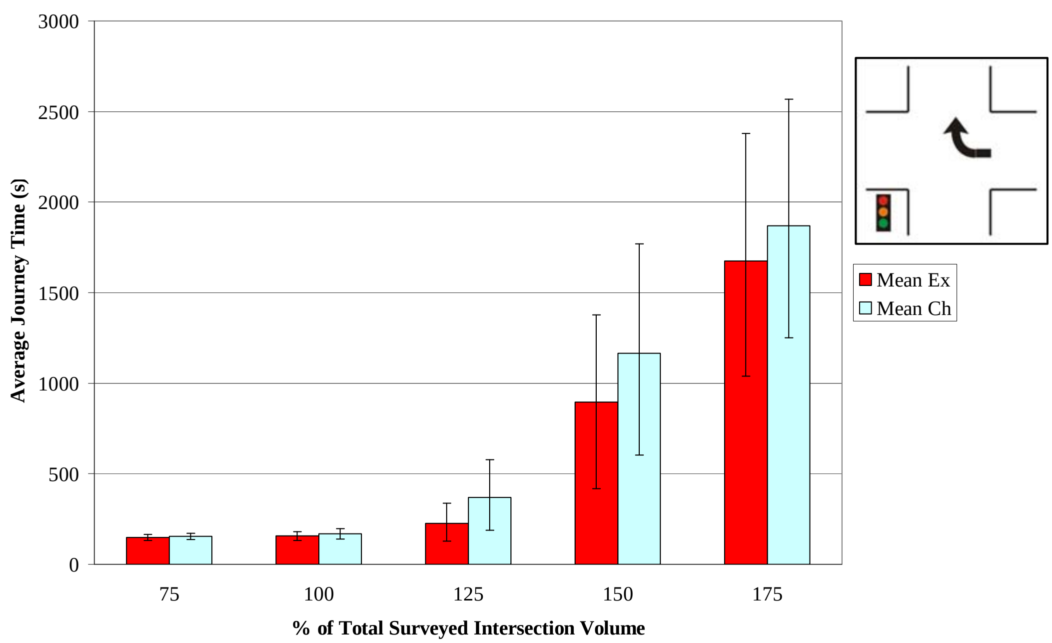


Figure A6.5.2 - Intersection 4, M1, Bealey Avenue (East) Right Turn Journey Time Comparison

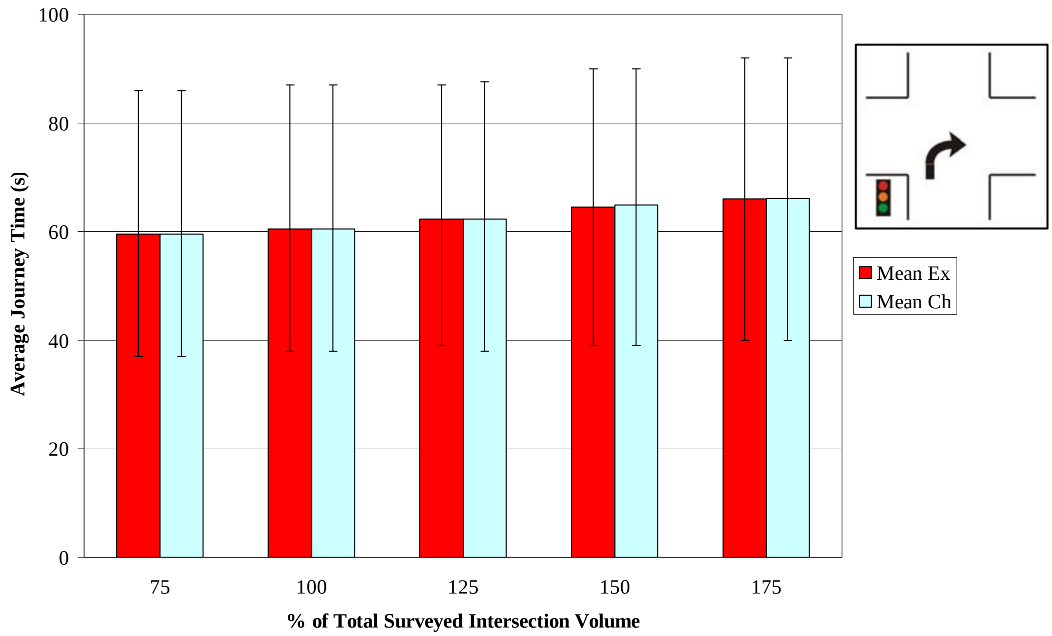


Figure A6.5.3 - Intersection 4, M1, Colombo Street (South) Right Turn Journey Time Comparison

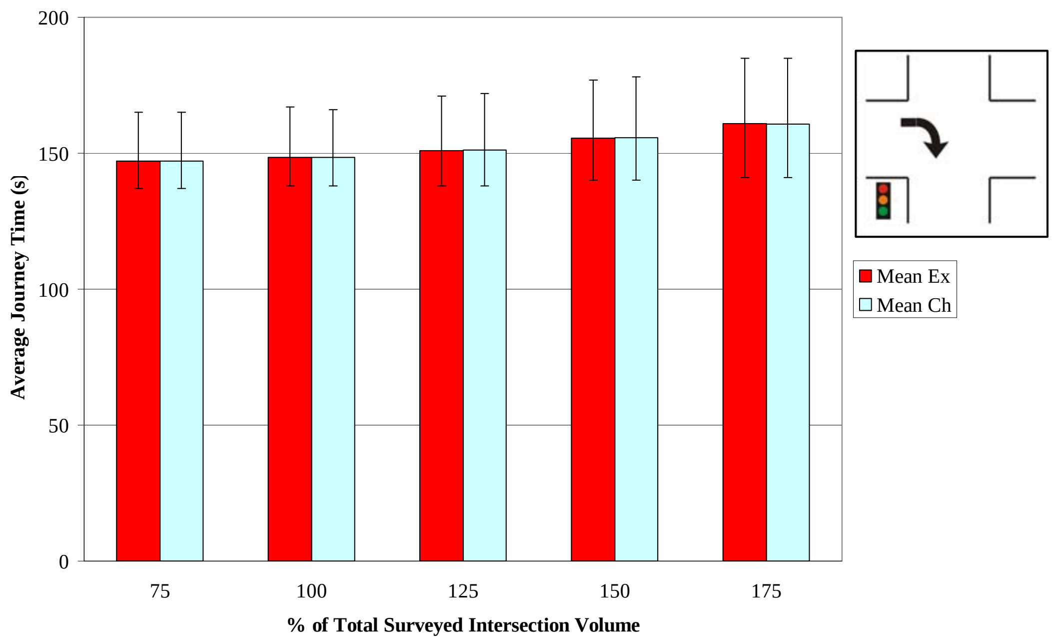


Figure A6.5.4 - Intersection 4, M1, Bealey Avenue (West) Right Turn Journey Time Comparison

Figure A6.5.1 to Figure A6.5.4 show that there is very little difference in the right turn journey times on the north, south and west approaches. The right turn from Bealey Avenue (East) is clearly the most critical movement and very sensitive to increases in total intersection volume. Average journey times that reach in the order of 1,600 seconds (around 27 minutes) indicate that this approach has essentially broken down. Journey times of this size would not occur in a real network however they show that the existing rule does operate more efficiently than the changed rule for this right turn movement.

Figure A6.5.5 to Figure A6.5.8 present journey time comparisons for the four left turn movements at the intersection.

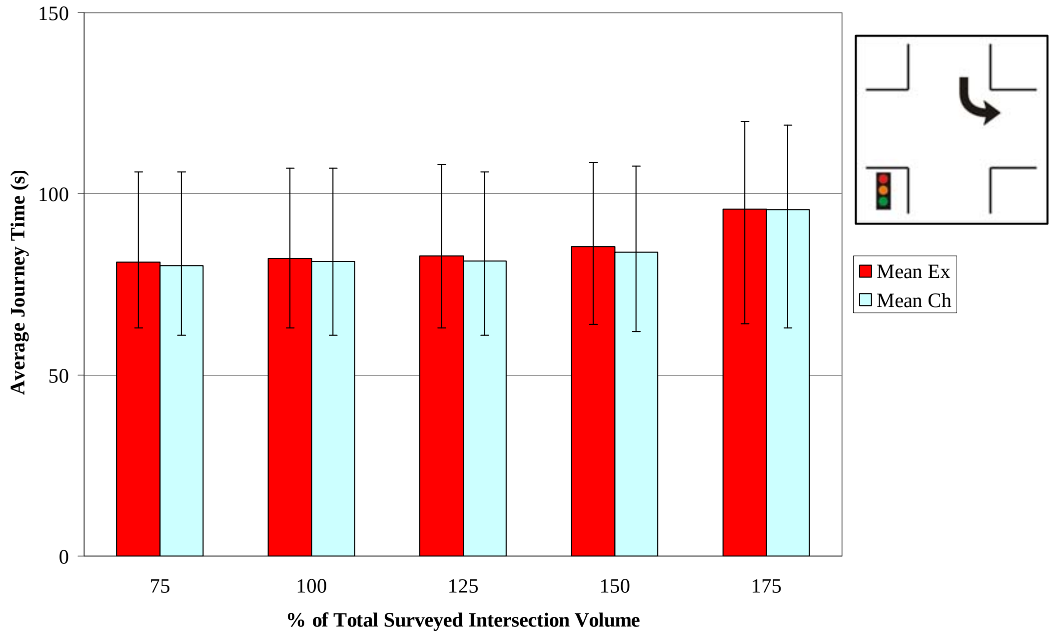


Figure A6.5.5 - Intersection 4, M1, Colombo Street (North) Left Turn Journey Time Comparison

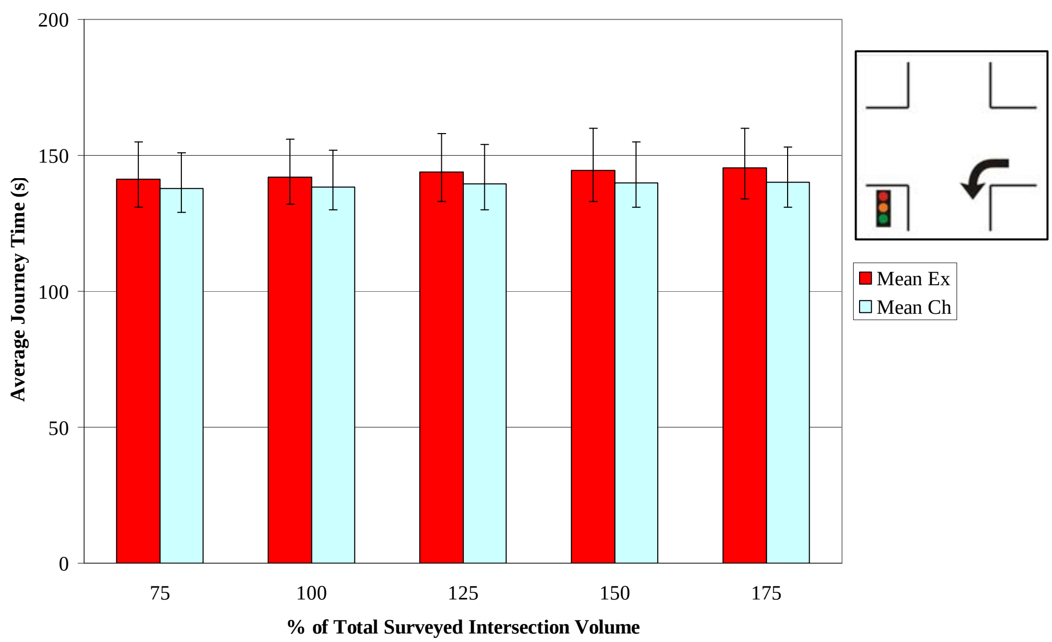


Figure A6.5.6 - Intersection 4, M1, Bealey Avenue (East) Left Turn Journey Time Comparison

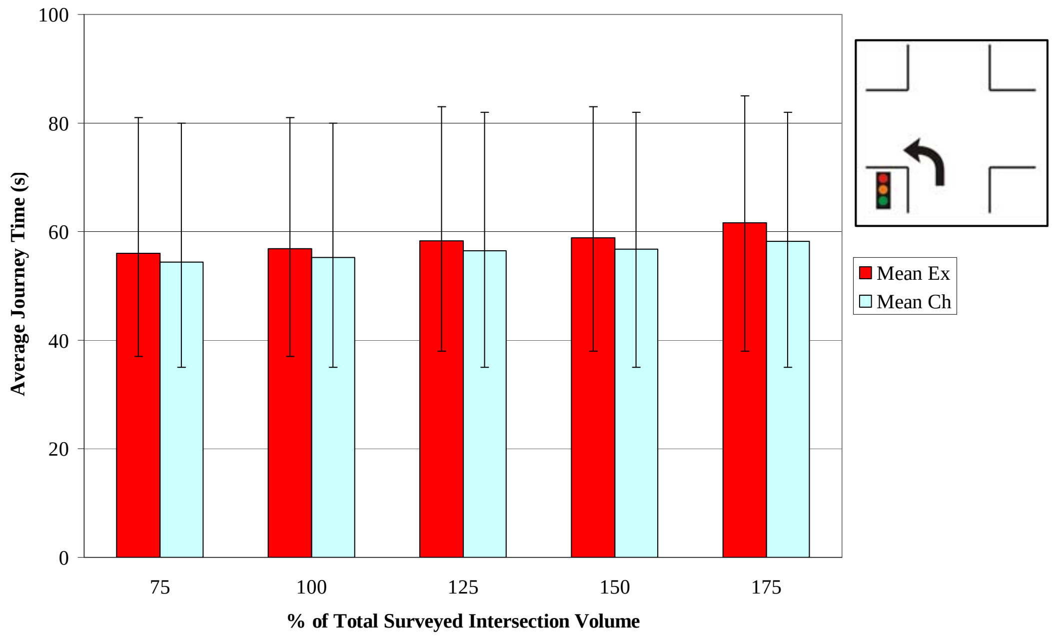


Figure A6.5.7 - Intersection 4, M1, Colombo Street (South) Left Turn Journey Time Comparison

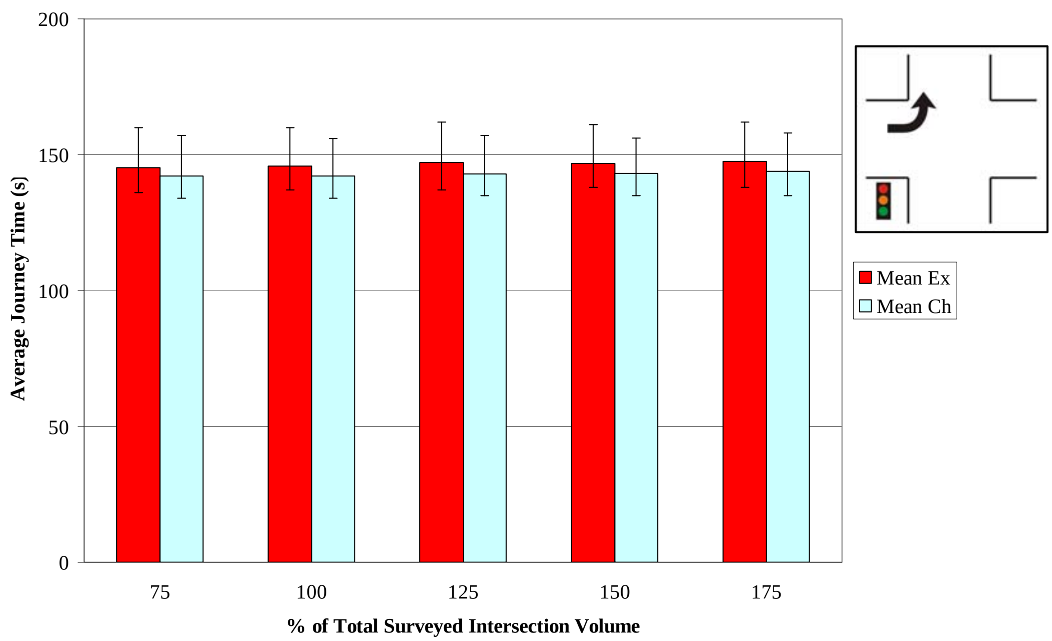


Figure A6.5.8 - Intersection 4, M1, Bealey Avenue (West) Left Turn Journey Time Comparison

All the left turn movements show a consistent pattern of a decrease in journey time that remains relatively consistent regardless of the total volume through the intersection.

Figure A6.5.9 shows the average journey time for all movements through the intersection under each rule.

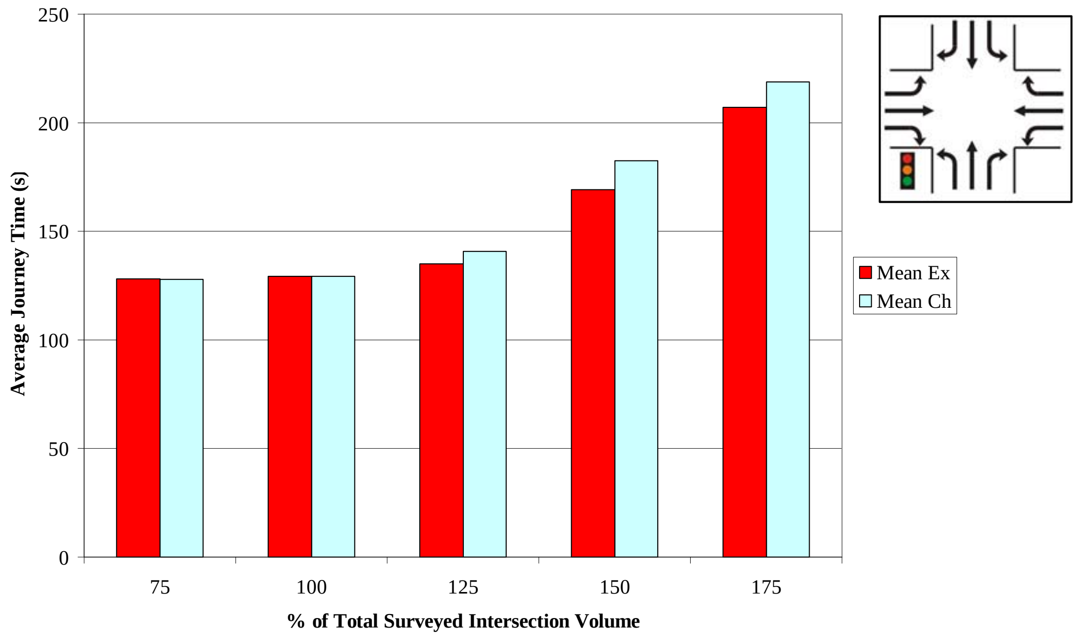


Figure A6.5.9 - Intersection 4, M1, Total Intersection Journey Time Comparison

A6.5.2 Journey Times Method 2

Figure A6.5.10 to Figure A6.5.13 present journey time comparisons for the four right turn movements at the intersection.

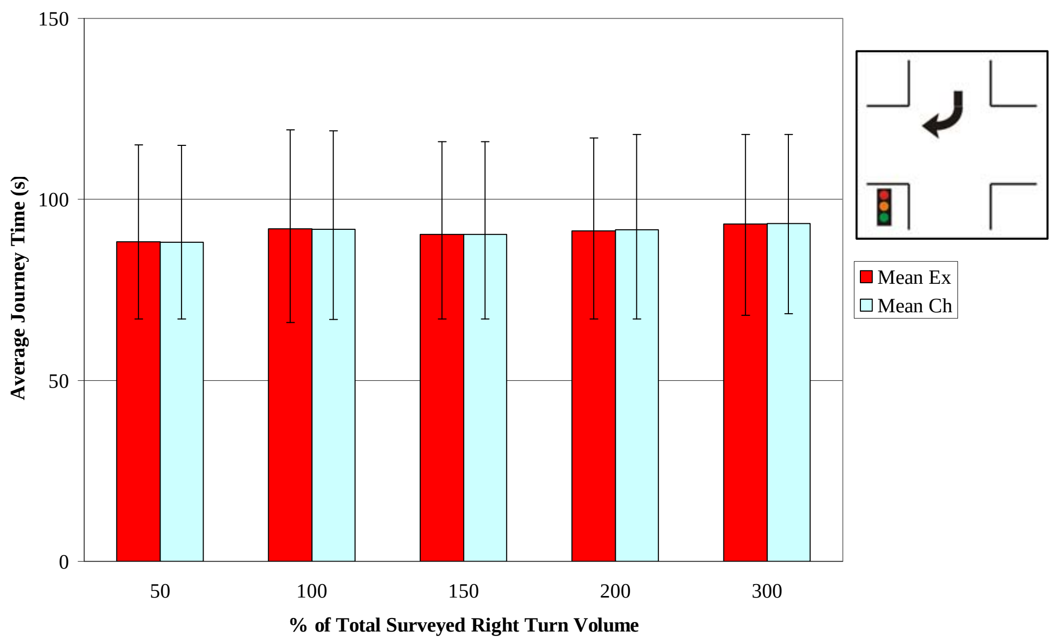


Figure A6.5.10 - Intersection 4, M2, Colombo Street (North) Right Turn Journey Time Comparison

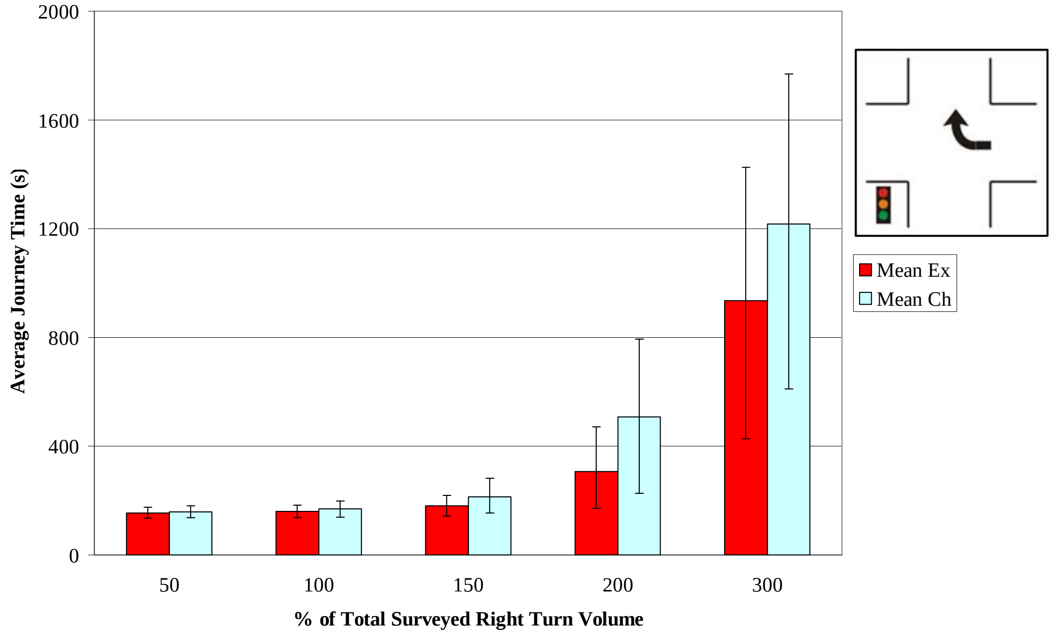


Figure A6.5.11 - Intersection 4, M2, Bealey Avenue (East) Right Turn Journey Time Comparison

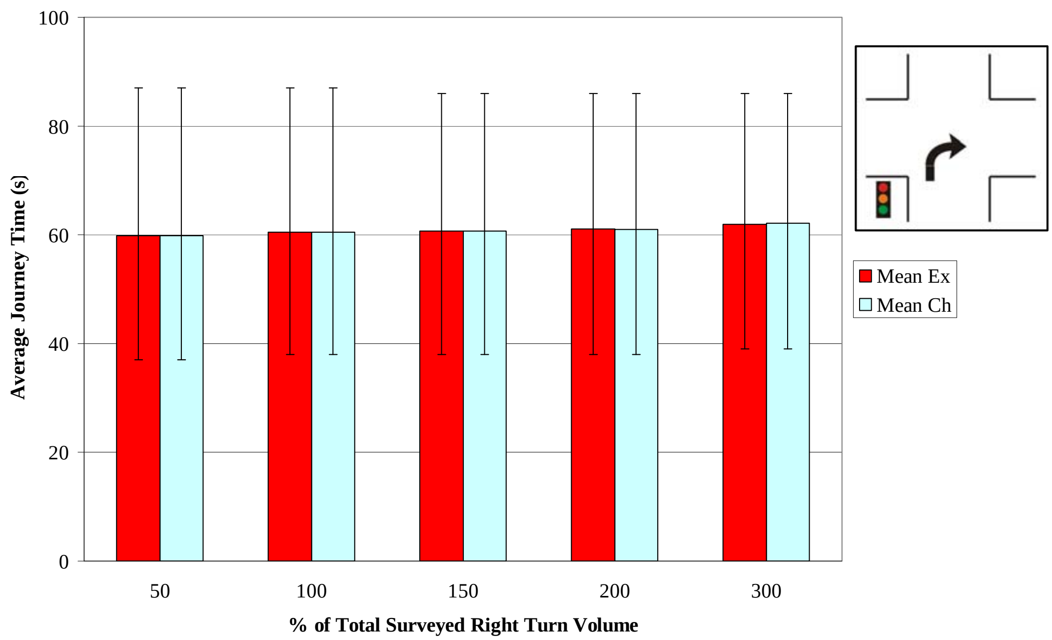


Figure A6.5.12 - Intersection 4, M2, Colombo Street (South) Right Turn Journey Time Comparison

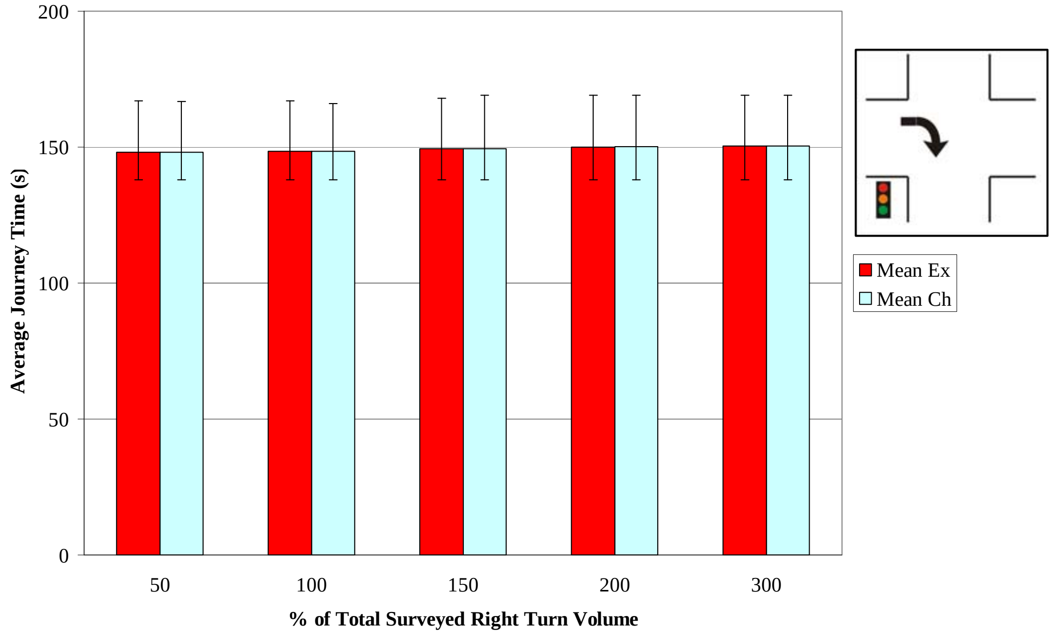


Figure A6.5.13 - Intersection 4, M2, Bealey Avenue (West) Right Turn Journey Time Comparison

Figure A6.5.10 to Figure A6.5.13 show that there is very little difference in the right turn journey times on the north, south and west approaches. The right turn from Bealey Avenue (East) is clearly the most critical movement and very sensitive to increases in the proportion of right turning vehicles.

The journey times that reach up to 1,200 seconds (around 20 minutes) that this approach has essentially broken down. Journey times of this size would not occur in a real network however they show that the existing rule does operate more efficiently than the changed rule for this right turn movement.

Figure A6.5.14 to Figure A6.5.17 present journey time comparisons for the four left turn movements at the intersection.

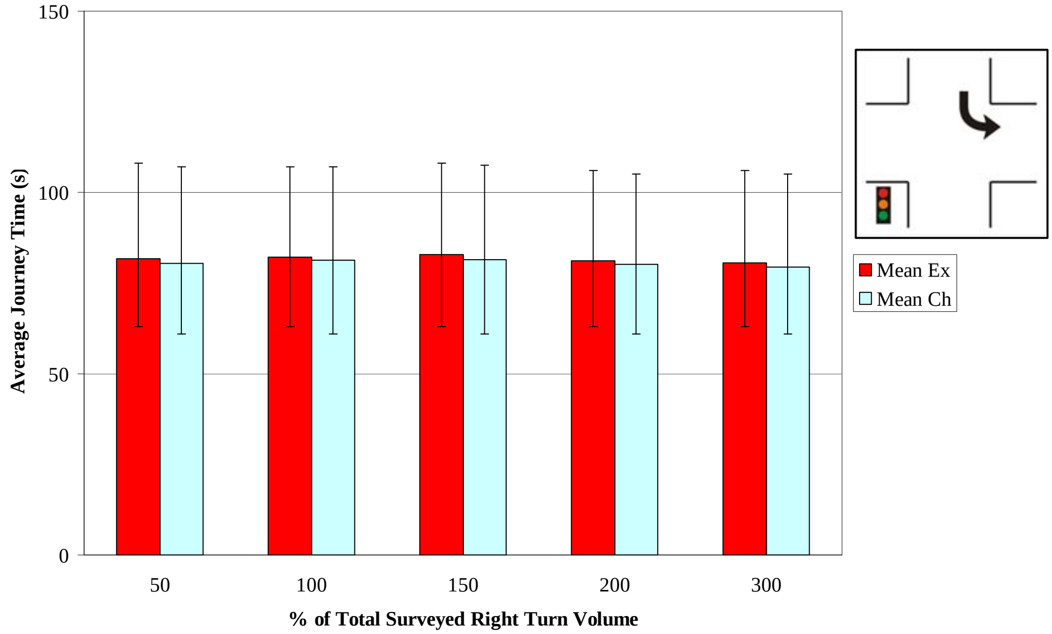


Figure A6.5.14 - Intersection 4, M2, Colombo Street (North) Left Turn Journey Time Comparison

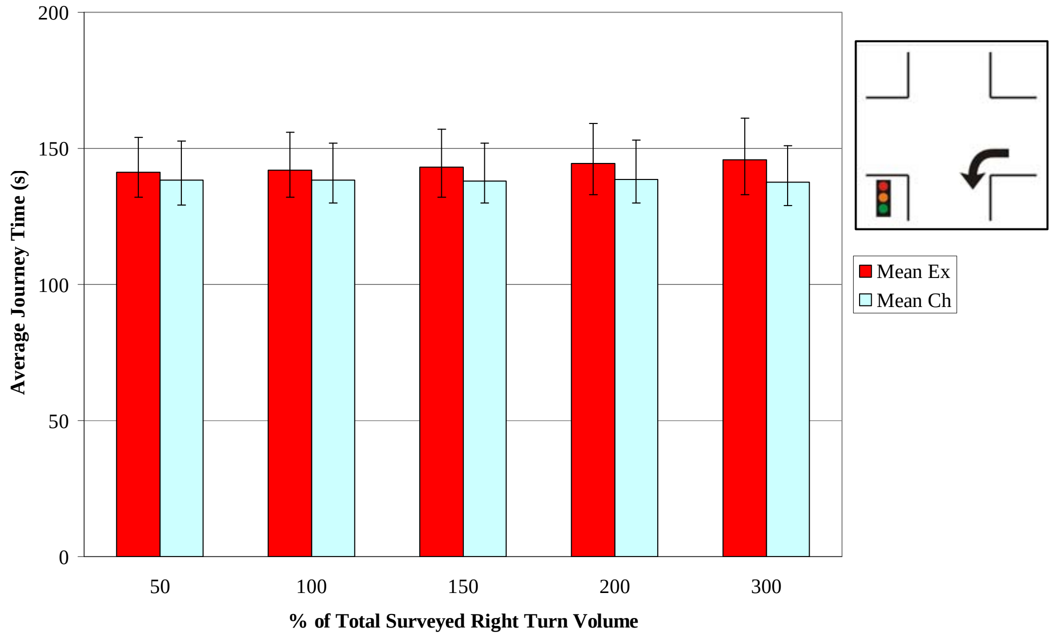


Figure A6.5.15 - Intersection 4, M2, Bealey Avenue (East) Left Turn Journey Time Comparison

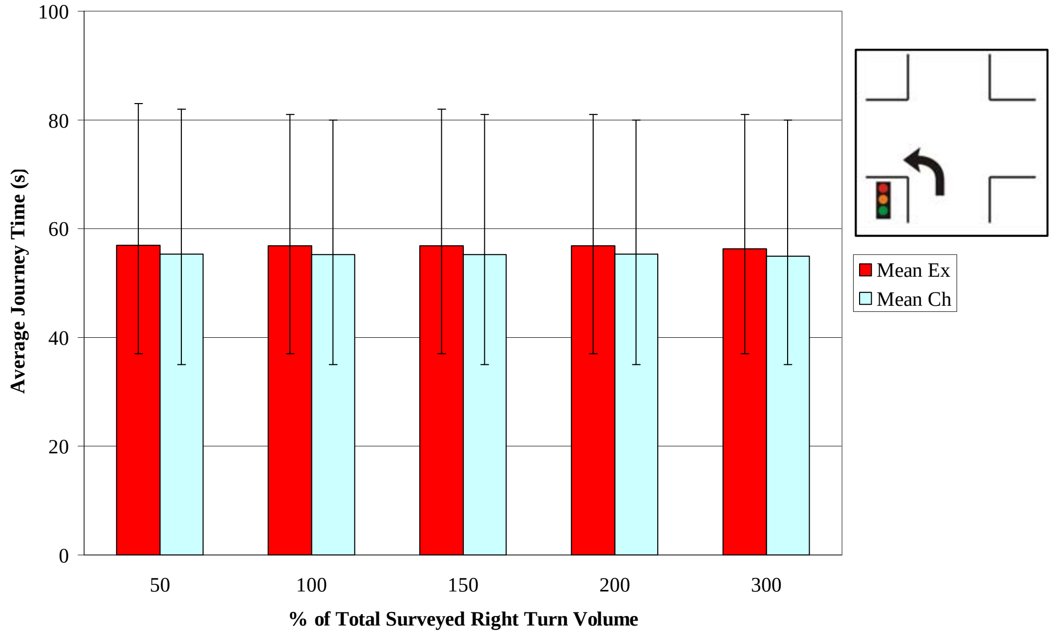


Figure A6.5.16 - Intersection 4, M2, Colombo Street (South) Left Turn Journey Time Comparison

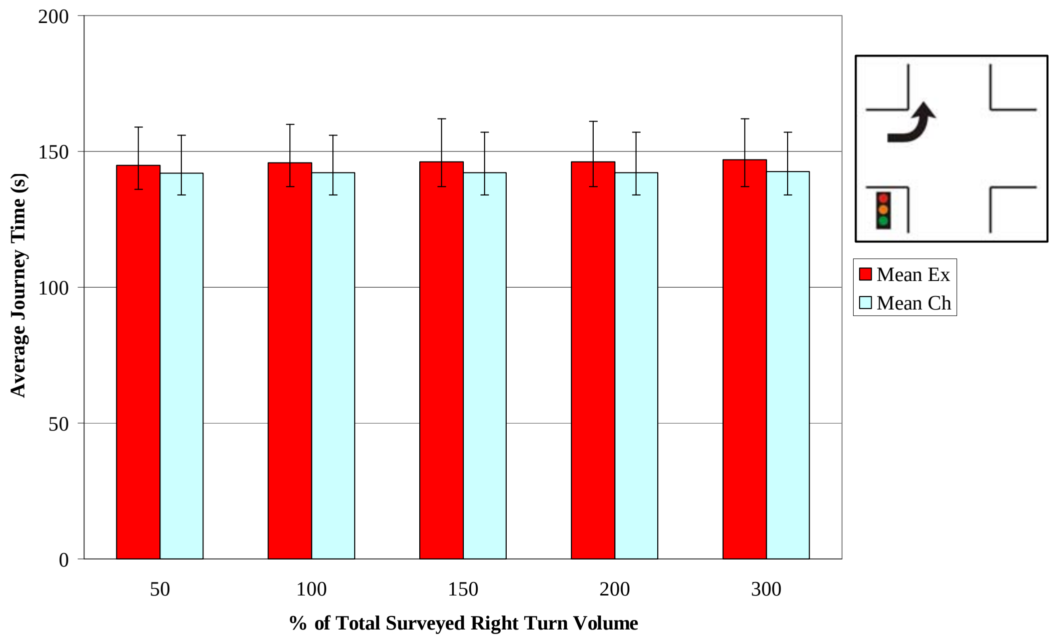


Figure A6.5.17 - Intersection 4, M2, Bealey Avenue (West) Left Turn Journey Time Comparison

All the left turn movements show a consistent pattern of a decrease in journey time that remains relatively consistent regardless of the proportion of right turning vehicles through the intersection.

Figure A6.5.18 shows the average journey time for all movements through the intersection under each rule.

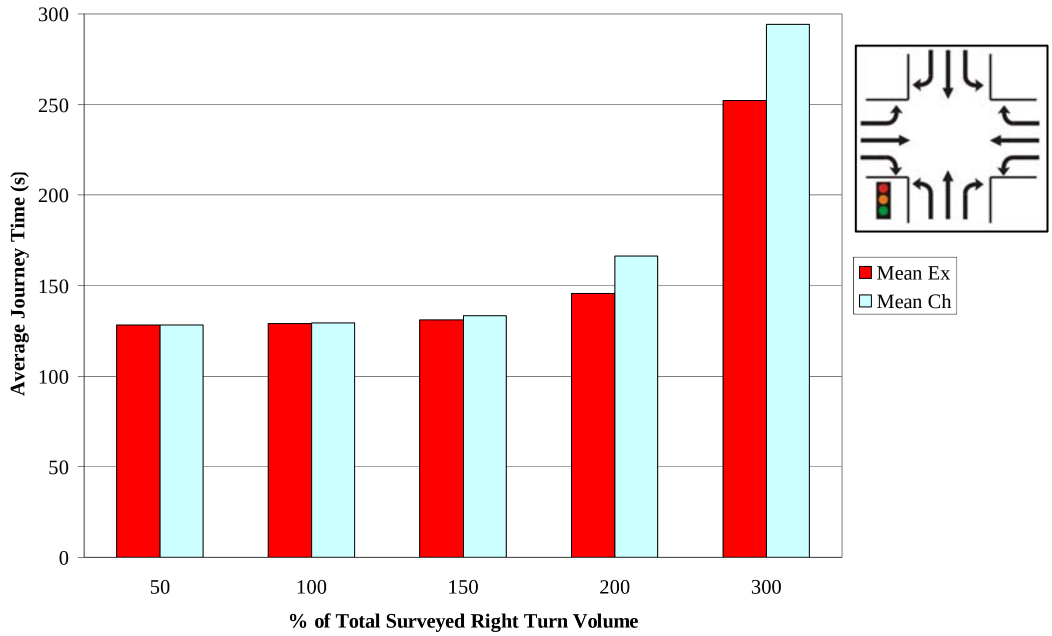


Figure A6.5.18 - Intersection 4, M2, Total Intersection Journey Time Comparison

The overall average journey time is similar for the first three volume scenarios however the existing rule proves more efficient in the last two scenarios.

Table A6.5.1 summarises the average journey time for all movements for each volume scenario.

Table A6.5.1 - Intersection 4, M2, Average Journey Time Comparison

Approach	Mvt	Average Journey Time (seconds/vehicle) for Various % Scenarios									
		50%		100%		150%		200%		300%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Colombo Street (North)	L	82	80	82	81	83	81	81	80	81	79
	T	85	85	86	86	86	86	88	88	90	90
	R	88	88	92	92	90	90	91	92	93	93
Bealey Avenue (East)	L	141	138	142	138	143	138	144	139	146	138
	T	137	137	137	137	137	137	137	137	137	137
	R	155	158	161	169	181	214	307	508	935	1217
Colombo Street (South)	L	57	55	57	55	57	55	57	55	56	55
	T	55	55	57	57	57	58	57	57	60	60
	R	60	60	60	60	61	61	61	61	62	62
Bealey Avenue (West)	L	145	142	146	142	146	142	146	142	147	142
	T	141	141	141	141	141	141	141	141	140	140
	R	148	148	148	148	149	150	150	150	150	150
Total	All	128	128	129	129	131	133	146	166	252	294

The analysis show that there is very little difference in the right turn journey times on the north, south and west approaches. The right turn from Bealey Avenue (East) is clearly the most critical movement and very sensitive to increases in the proportion of right turning vehicles.

The journey times that reach up to 1,200 seconds (around 20 minutes) that this approach has essentially broken down. Journey times of this size would not occur in a real network however they show that the existing rule does operate more efficiently than the changed rule for this right turn movement.

Table A6.5.2 presents a comparison for the increase or decrease in journey time for each right turn and the opposing left turn.

Table A6.5.2 - Intersection 4, M1, Right and Left Turn Journey Time Changes

Movement	Change in Average Journey Time (seconds/vehicle) for Various % Scenarios				
	75%	100%	125%	150%	175%
Colombo Street (North) R	-0.1	-0.2	0.0	0.2	0.1
Colombo Street (South) L	-1.6	-1.6	-1.5	-1.5	-1.3
Bealey Avenue (East) R	3.7	8.0	33.1	200.9	281.4
Bealey Avenue (West) L	-2.8	-3.6	-4.1	-4.0	-4.5
Colombo Street (South) R	-0.0	0.0	0.0	-0.1	0.1
Colombo Street (North) L	-1.3	-0.9	-1.4	-1.0	-1.1
Bealey Avenue (West) R	-0.1	-0.0	0.1	0.1	-0.0
Bealey Avenue (East) L	-2.7	-3.6	-5.0	-5.9	-8.1

The table shows that journey times for all the left turn movements decrease by between 0.1 and 8.1 seconds. The change generally increases slowly as the proportion of right turning vehicles through the intersection increases.

The right turn journey times on the north, south and west approaches are not significantly affected whereas the east approach is dramatically affected and performs better under the existing rule than the changed rule.

A6.5.3 Queue Lengths Method 1

Figure A6.5.19 to Figure A6.5.22 to present queue length comparisons for all lanes accommodating right turns at the intersection. Both Bealey Avenue approaches have dedicated right turn lanes. Both Colombo Street approaches have shared through and right lanes.

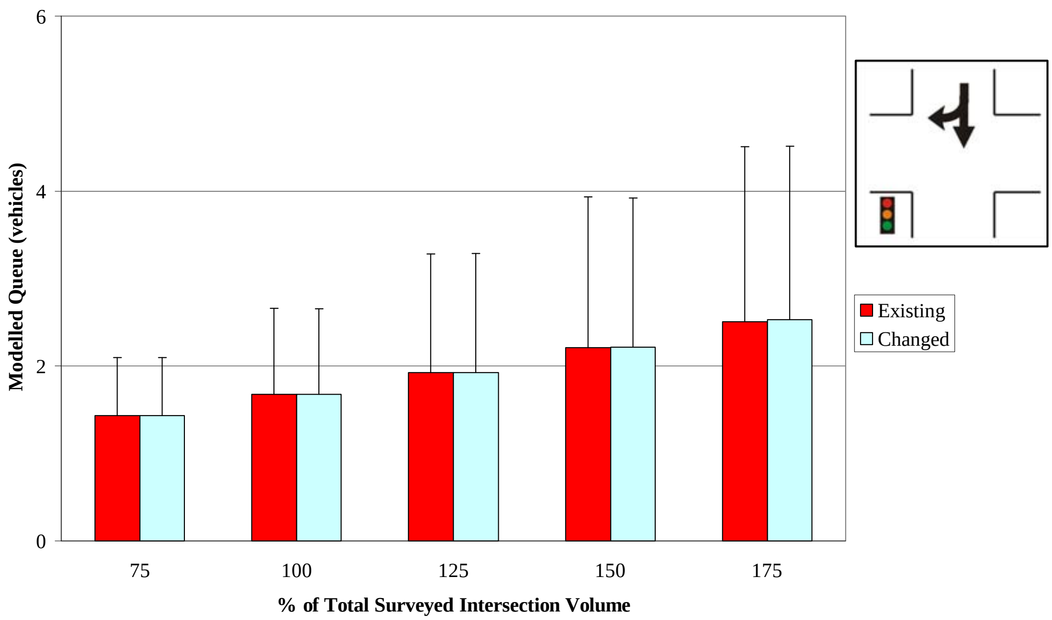


Figure A6.5.19 - Intersection 4, M1, Colombo Street (North) Shared Through & Right Queue Comparison

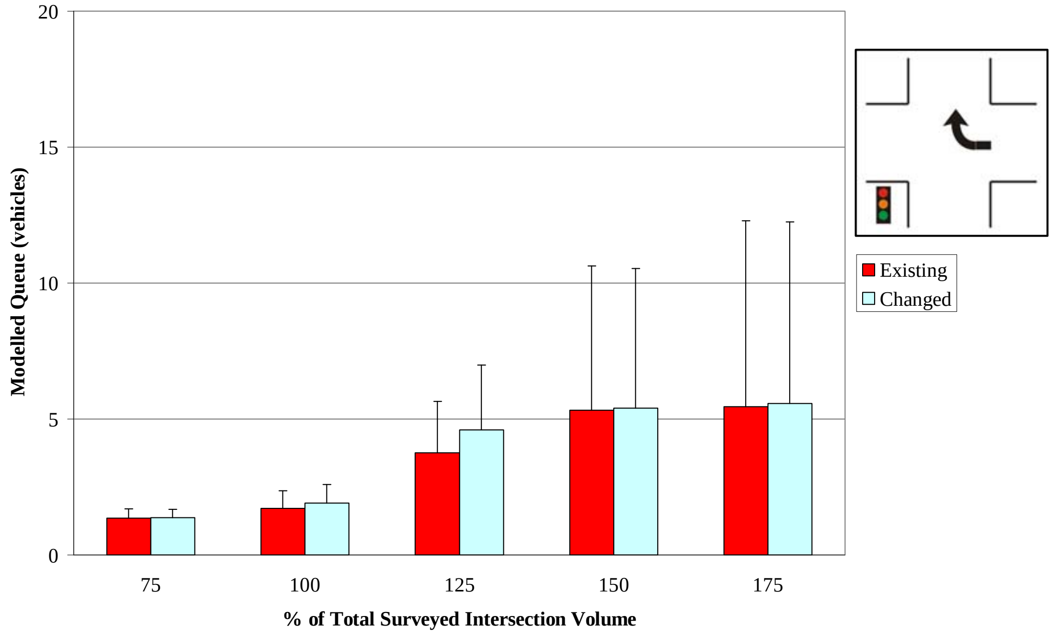


Figure A6.5.20 - Intersection 4, M1, Bealey Avenue (East) Right Turn Queue Comparison

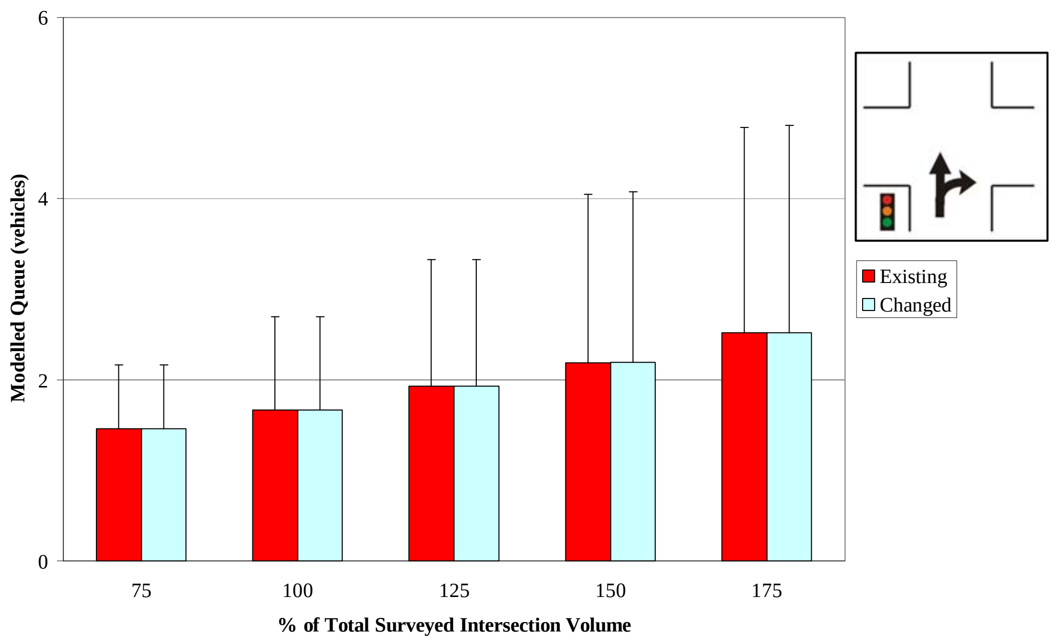


Figure A6.5.21 - Intersection 4, M1, Colombo Street (South) Through & Right Queue Comparison

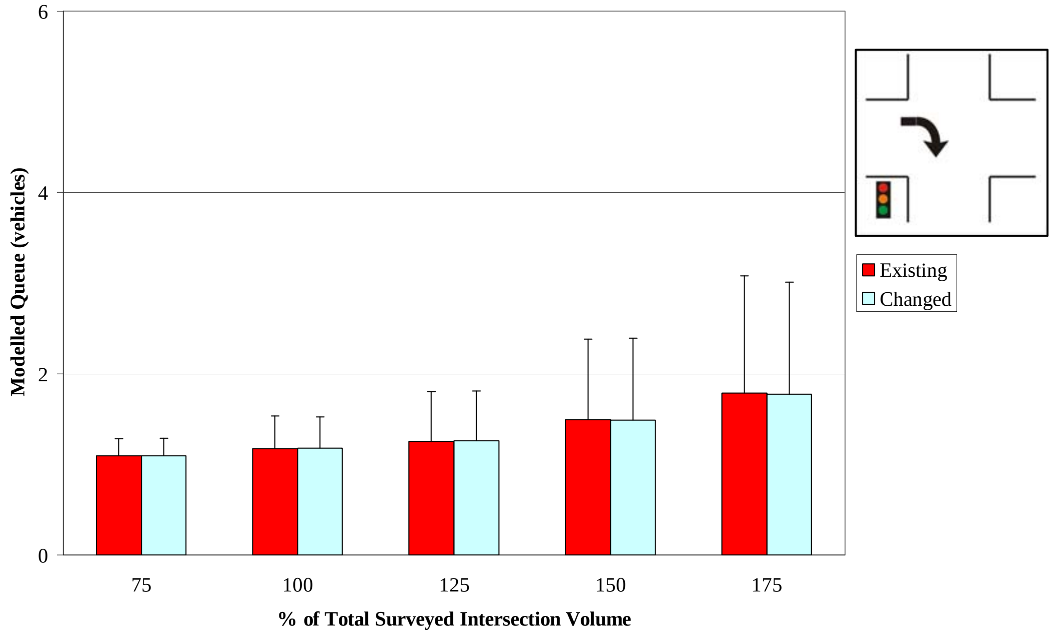


Figure A6.5.22 - Intersection 4, M1, Bealey Avenue (West) Right Turn Queue Comparison

Figure A6.5.19 to Figure A6.5.22 show that there is very little difference between the rules for both the dedicated right turn lanes on Bealey Avenue and the shared through and right lanes on Colombo Street.

Figure A6.5.23 to Figure A6.5.26 present queue length comparisons for all lanes accommodating left turns at the intersection. All approaches have dedicated left turn lanes.

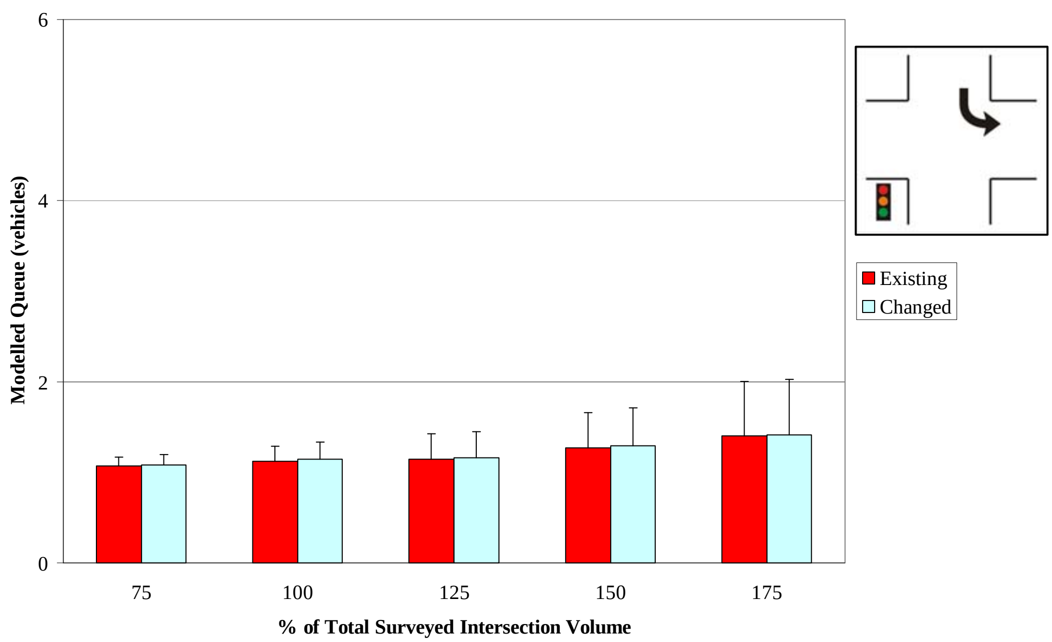


Figure A6.5.23 - Intersection 4, M1, Colombo Street (North) Left Turn Queue Comparison

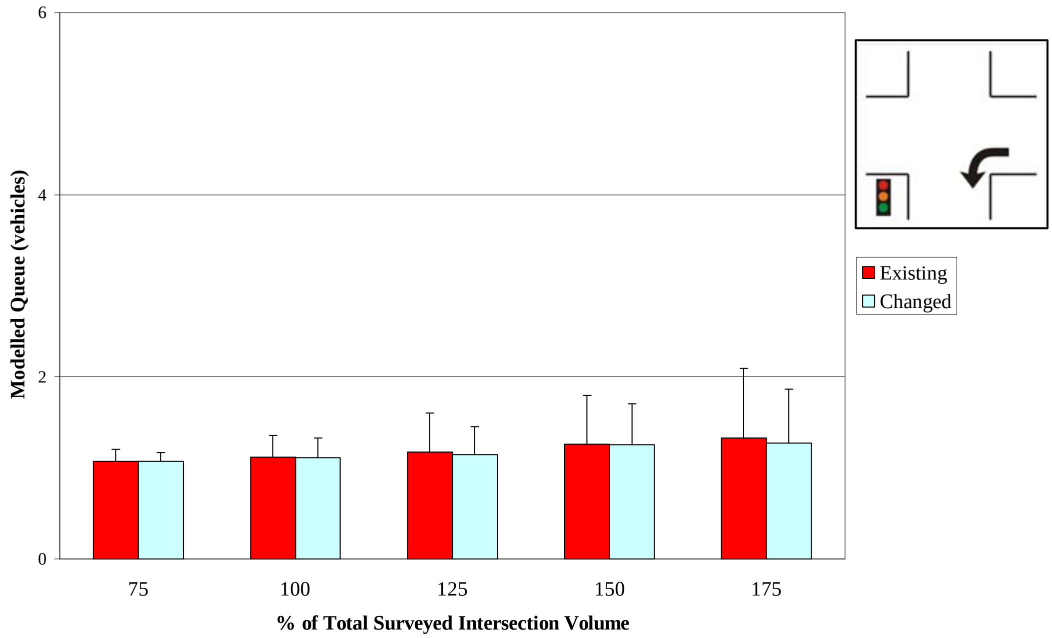


Figure A6.5.24 - Intersection 4, M1, Bealey Avenue (East) Left Turn Queue Comparison

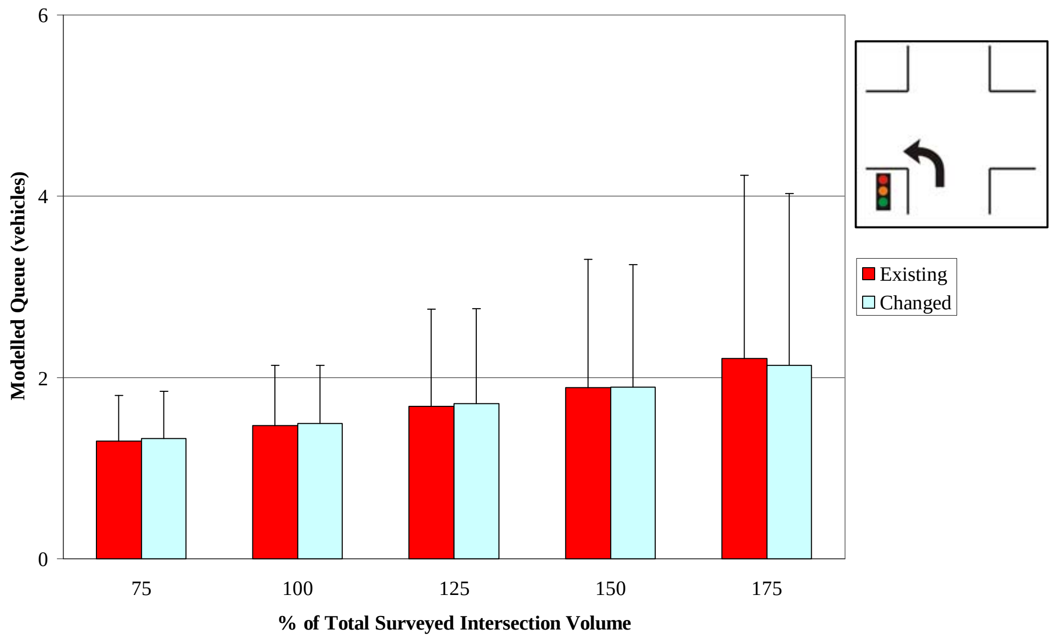


Figure A6.5.25 - Intersection 4, M1, Colombo Street (South) Left Turn Queue Comparison

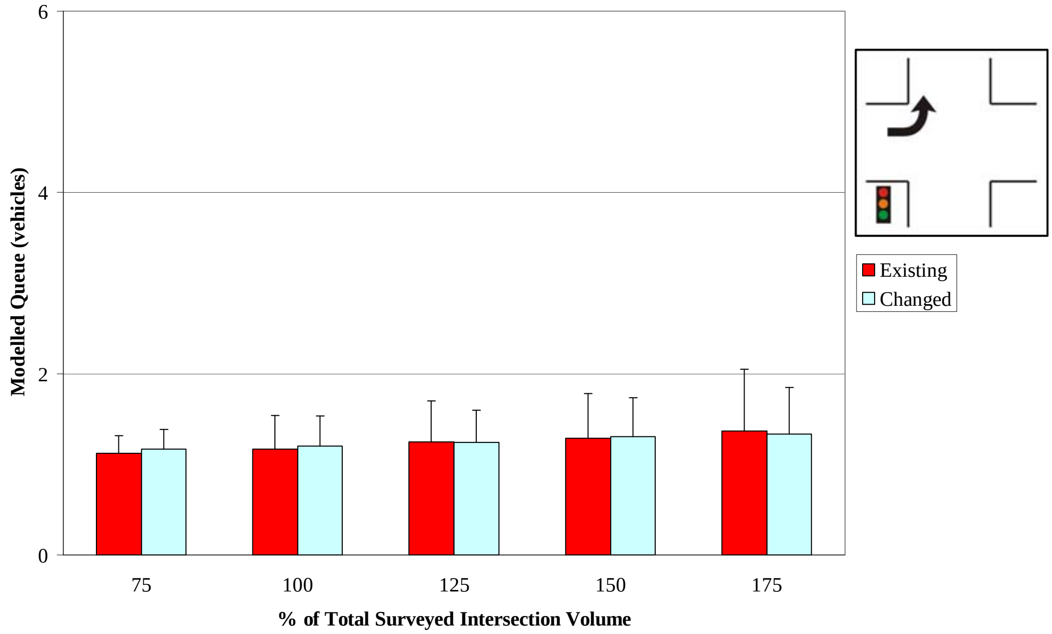


Figure A6.5.26 - Intersection 4, M1, Bealey Avenue (West) Left Turn Queue Comparison

Overall the queuing activity in all the left turn lanes is moderate and there is very little difference in the queue lengths under each rule.

A6.5.4 Queue Lengths Method 2

Figure A6.5.27 to Figure A6.5.30 present queue length comparisons for all lanes accommodating right turns at the intersection. Both Bealey Avenue approaches have dedicated right turn lanes. Both Colombo Street approaches have shared through and right lanes.

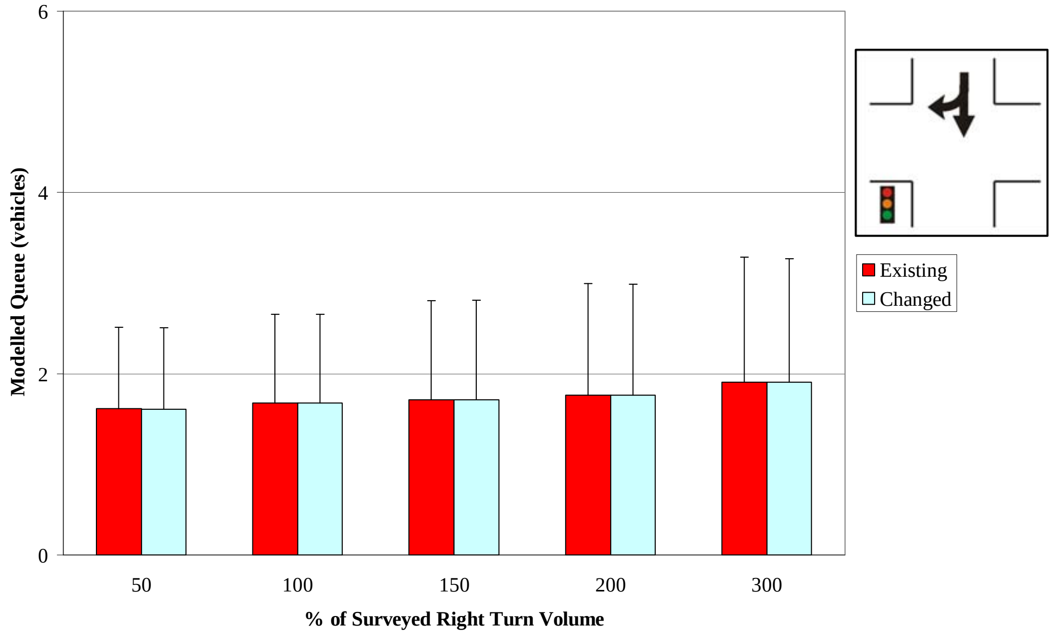


Figure A6.5.27 - Intersection 4, M2, Colombo Street (North) Shared Through and Right Turn Queue Comparison

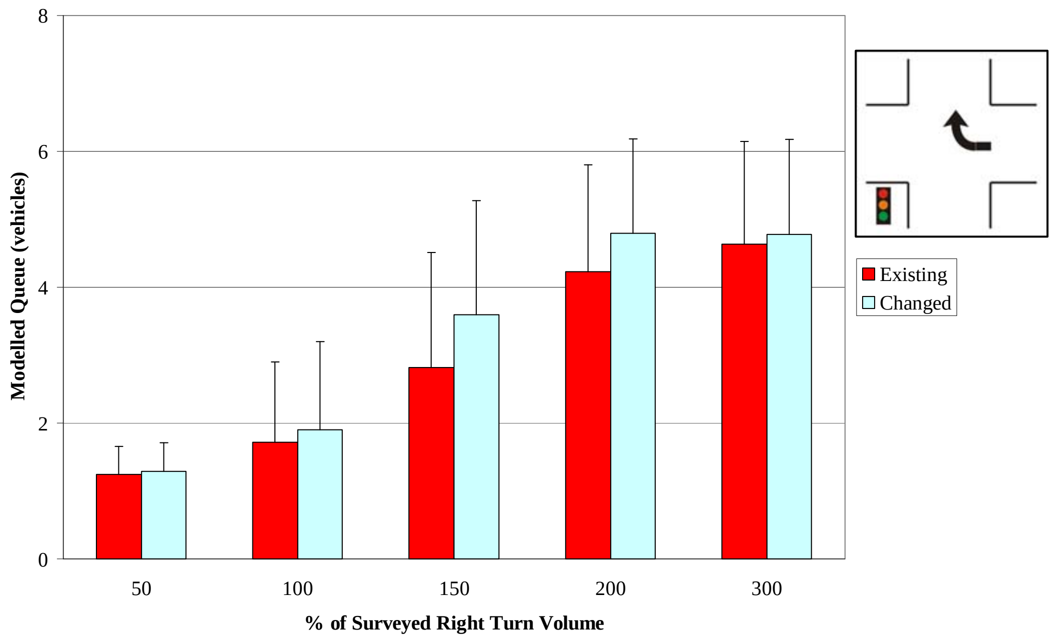


Figure A6.5.28 - Intersection 4, M2, Bealey Avenue (East) Right Turn Queue Comparison

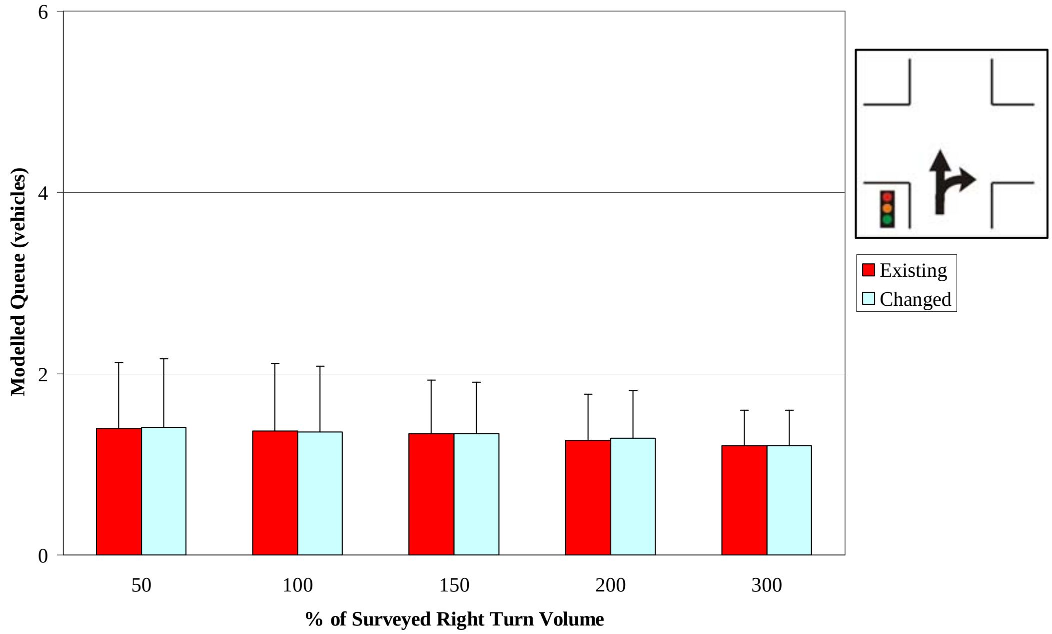


Figure A6.5.29 - Intersection 4, M2, Colombo Street (South) Shared Through & Right Queue Comparison

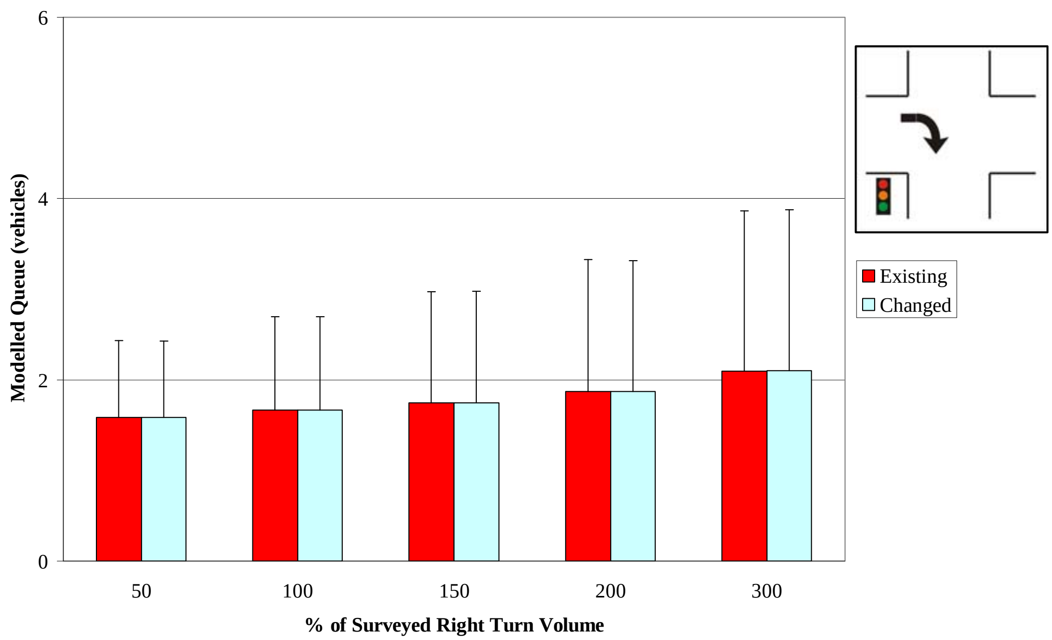


Figure A6.5.30 - Intersection 4, M2, Bealey Avenue (West) Right Turn Queue Comparison

Figure A6.5.27 to Figure A6.5.30 show very little difference in the modelled queues on the north, south and west approaches. The east approach shows that the right turn queue length increases with the changed rule and the difference grows as the proportion of right turning vehicles through the intersection increases.

Figure A6.5.31 to Figure A6.5.34 present queue length comparisons for all lanes accommodating left turns at the intersection. All approaches have dedicated left turn lanes.

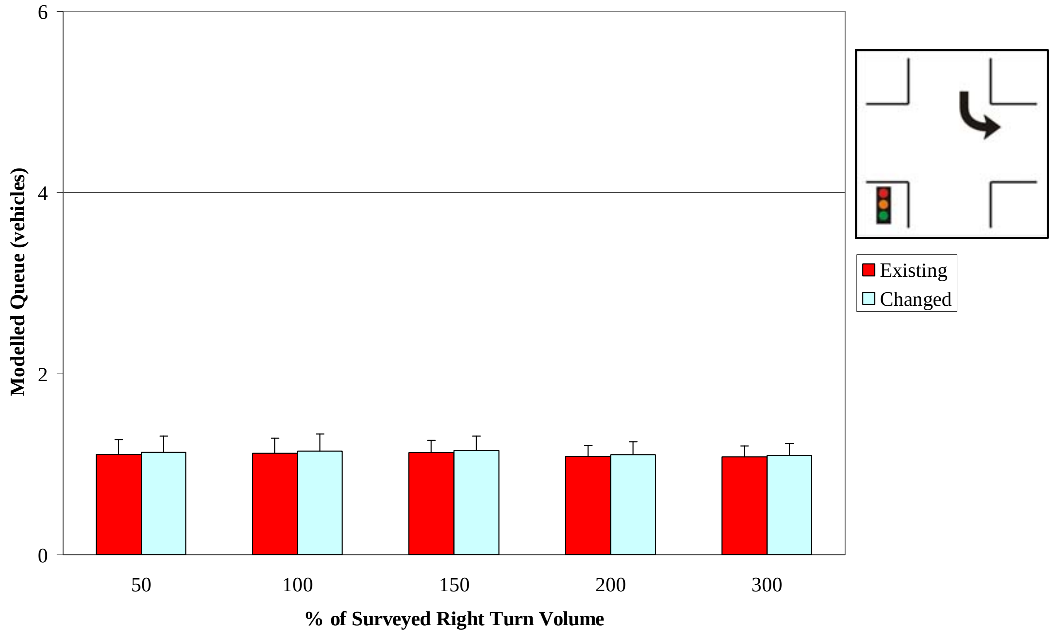


Figure A6.5.31 - Intersection 4, M2, Colombo Street (North) Left Turn Queue Comparison

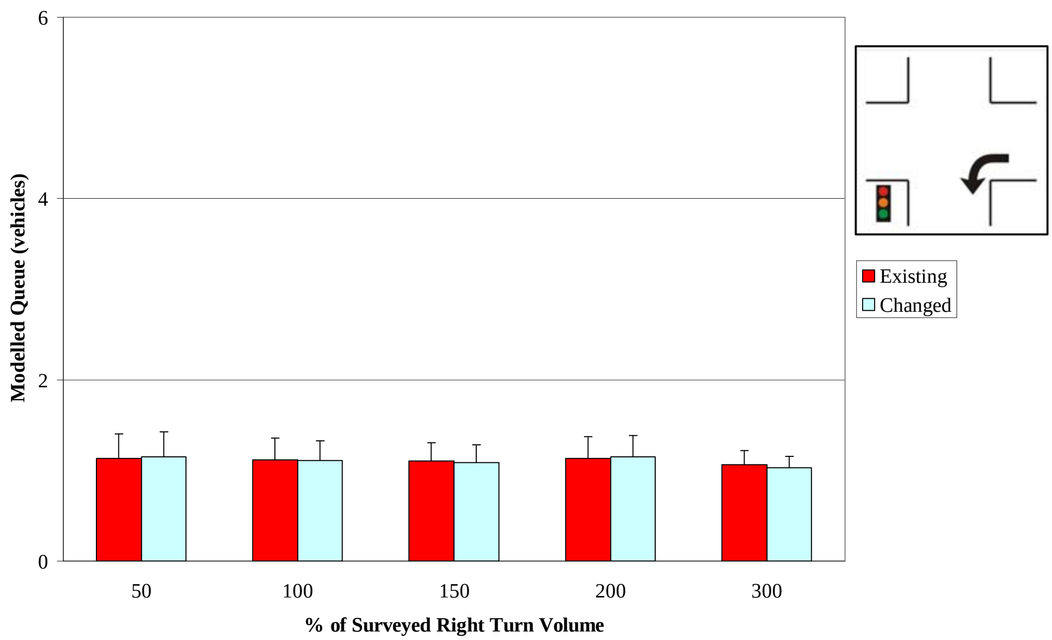


Figure A6.5.32 - Intersection 4, M2, Bealey Avenue (East) Left Turn Queue Comparison

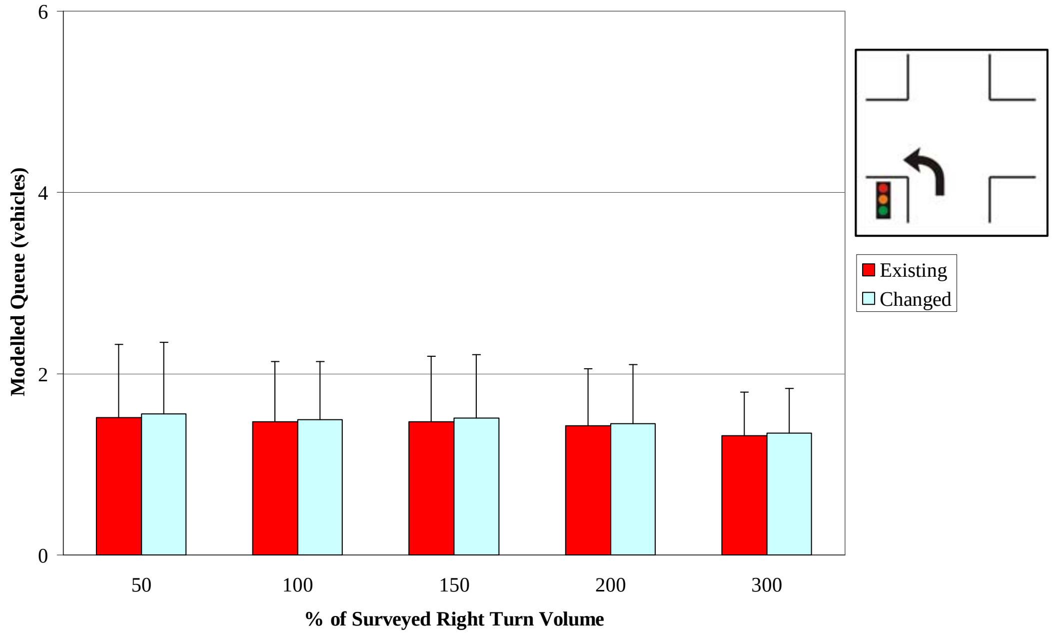


Figure A6.5.33 - Intersection 4, M2, Colombo Street (South) Left Turn Queue Comparison

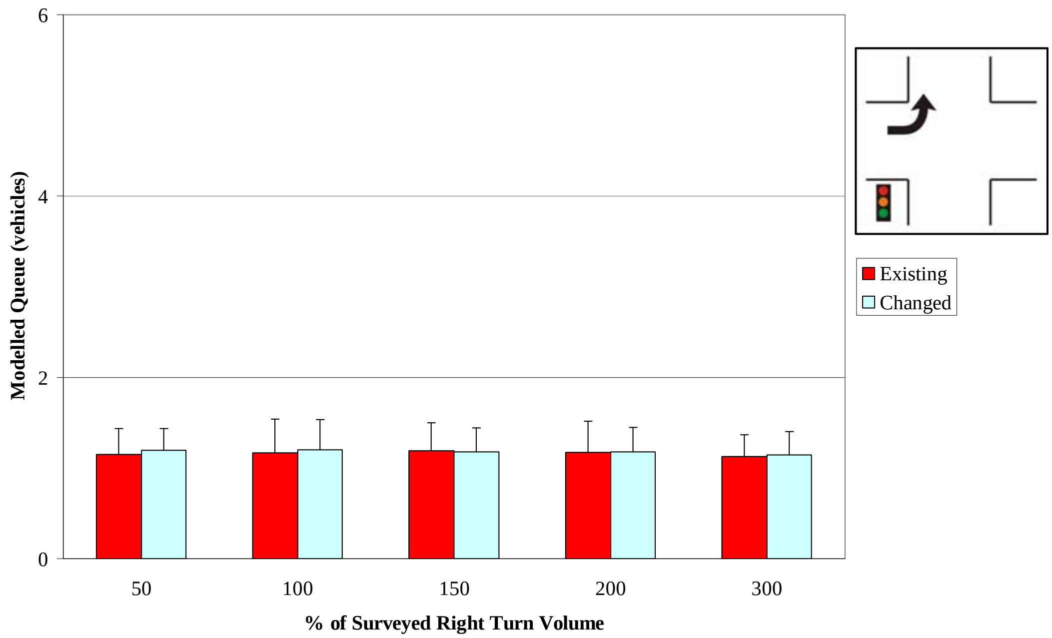


Figure A6.5.34 - Intersection 4, M2, Bealey Avenue (West) Left Turn Queue Comparison

Figure A6.5.31 to Figure A6.5.34 show very little difference in the modelled left turn queues between the existing and changed rule.

Table A6.5.3 summarises the average queue lengths for various volume scenarios.

Table A6.5.3 - Intersection 4 M2 Average Queue Comparison

Approach	Mvt	Average Queue Length (vehicles) for Various % Scenarios									
		50%		100%		150%		200%		300%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Colombo Street (North)	L	1.1	1.1	1.1	1.1	1.1	1.2	1.1	1.1	1.1	1.1
	TR	1.6	1.6	1.7	1.7	1.7	1.7	1.8	1.8	1.9	1.9
Bealey Avenue (East)	L	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.1	1.0
	T	2.0	2.0	1.9	1.9	1.8	1.9	1.8	1.8	1.6	1.6
	T	1.5	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.3	1.3
	T	1.3	1.3	1.3	1.3	1.7	2.6	7.7	17.8	32.2	41.8
	R	1.2	1.3	1.7	1.9	2.8	3.6	4.2	4.8	4.6	4.8
Colombo Street (South)	L	1.5	1.6	1.5	1.5	1.5	1.5	1.4	1.5	1.3	1.3
	TR	1.6	1.6	1.7	1.7	1.7	1.7	1.9	1.9	2.1	2.1
Bealey Avenue (West)	L	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.1
	T	2.1	2.1	2.1	2.1	1.9	1.9	1.8	1.8	1.6	1.6
	T	1.6	1.6	1.5	1.5	1.4	1.5	1.4	1.4	1.3	1.3
	T	1.4	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.2	1.2

Table A6.5.3 shows that the left turn queue lengths are very similar under both rules with some scenarios showing a small reduction under the changed rule.

The right turn queue lengths show a similar pattern in reverse, with similar queue lengths and some scenarios showing a small increase under the changed rule.

The right turn from Bealey Avenue (East) shows a slight increase in the right lane itself however the queuing in the adjacent through lane increases significantly as the proportion of right turning vehicles through the intersection increases. As for the results observed for the journey times for this movement, the existing rule results in shorter queues.

A6.6 Full Journey Time Analysis Results

Method 1 Existing Rule							
Mean Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Colombo Street (North)	L	81.2	82.1	82.8	85.4	95.7
NT		T	83.9	86.2	87.9	93.2	106.2
NR		R	89.1	91.9	91.9	96.7	109.3
EL	Bealey Avenue (East)	L	141.2	141.9	143.8	144.6	145.4
ET		T	136.9	137.1	137.8	138.8	140.5
ER		R	151.2	161.1	255.5	887.7	1613.4
SL	Colombo Street (South)	L	56.0	56.9	58.3	58.9	61.6
ST		T	55.7	56.9	58.3	59.9	62.8
SR		R	59.5	60.5	62.3	64.5	66.0
WL	Bealey Avenue (West)	L	145.2	145.7	147.2	146.8	147.4
WT		T	140.7	141.1	141.4	142.0	142.9
WR		R	147.2	148.4	151.0	155.6	160.9
All Movements		All	128.1	129.2	134.9	169.1	207.0
Median Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Colombo Street (North)	L	75.0	77.0	77.0	83.0	89.0
NT		T	81.0	85.0	87.0	92.0	100.0
NR		R	89.0	91.0	91.0	96.0	104.0
EL	Bealey Avenue (East)	L	137.0	138.0	140.0	141.0	142.0
ET		T	132.0	133.0	133.0	134.0	136.0
ER		R	148.0	157.0	225.0	896.0	1674.0
SL	Colombo Street (South)	L	51.0	53.0	55.0	55.0	60.0
ST		T	53.0	55.0	56.0	59.0	62.0
SR		R	55.0	57.0	61.0	63.0	66.0
WL	Bealey Avenue (West)	L	142.0	143.0	143.0	144.0	145.0
WT		T	137.0	137.0	137.0	138.0	139.0
WR		R	144.0	145.0	147.0	153.0	158.0
All Movements		All	134.0	135.0	135.0	136.0	137.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Colombo Street (North)	L	63.0	63.0	63.0	64.0	64.1
NT		T	61.0	62.0	63.0	64.0	67.0
NR		R	65.0	66.0	67.0	69.0	73.0
EL	Bealey Avenue (East)	L	131.0	132.0	133.0	133.0	134.0
ET		T	127.0	127.0	127.0	128.0	128.0
ER		R	135.0	137.0	160.0	411.1	979.4
SL	Colombo Street (South)	L	37.0	37.0	38.0	38.0	38.0
ST		T	33.0	34.0	34.0	34.6	35.0
SR		R	37.0	38.0	39.0	39.0	40.0
WL	Bealey Avenue (West)	L	136.0	137.0	137.0	138.0	138.0
WT		T	131.0	131.0	132.0	132.0	132.0
WR		R	137.0	138.0	138.0	140.0	141.0
All Movements		All	95.0	97.0	97.0	103.0	112.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Colombo Street (North)	L	106.0	107.0	108.0	108.7	120.0
NT		T	110.0	112.0	112.0	118.0	144.0
NR		R	116.0	119.2	117.0	123.0	144.7
EL	Bealey Avenue (East)	L	155.0	156.0	158.0	160.0	160.0
ET		T	153.0	153.0	154.0	155.0	156.0
ER		R	170.0	184.0	368.0	1370.0	2318.0
SL	Colombo Street (South)	L	81.0	81.0	83.0	83.0	85.0
ST		T	81.0	82.0	84.0	85.0	88.0
SR		R	86.0	87.0	87.0	90.0	92.0
WL	Bealey Avenue (West)	L	160.0	160.0	162.0	161.0	162.1
WT		T	156.0	157.0	157.0	158.0	159.0
WR		R	165.0	167.0	171.0	177.0	185.0
All Movements		All	154.0	155.0	158.0	160.0	161.0

Method 1 Changed Rule							
Mean Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Colombo Street (North)	L	80.2	81.2	81.4	83.9	95.6
NT		T	84.0	86.2	88.1	93.0	108.9
NR		R	89.1	91.7	92.3	96.3	110.5
EL	Bealey Avenue (East)	L	137.8	138.3	139.4	140.0	140.1
ET		T	136.9	137.1	137.9	138.9	140.5
ER		R	153.2	169.2	369.6	1164.9	1869.2
SL	Colombo Street (South)	L	54.4	55.3	56.5	56.7	58.2
ST		T	55.7	57.1	58.5	60.2	63.2
SR		R	59.6	60.5	62.3	64.9	66.1
WL	Bealey Avenue (West)	L	142.3	142.1	143.0	143.2	143.9
WT		T	140.7	141.1	141.4	142.0	142.9
WR		R	147.1	148.4	151.2	155.7	160.7
All Movements		All	127.9	129.3	140.6	182.6	218.7
Median Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Colombo Street (North)	L	74.0	76.0	76.0	81.0	89.0
NT		T	81.0	85.0	87.0	92.0	101.0
NR		R	89.0	91.0	91.0	96.0	104.0
EL	Bealey Avenue (East)	L	134.0	134.0	135.0	136.0	136.0
ET		T	132.0	133.0	133.0	134.0	136.0
ER		R	150.0	165.0	331.0	1190.0	1960.0
SL	Colombo Street (South)	L	50.0	51.0	53.0	53.0	56.0
ST		T	53.0	56.0	56.0	59.0	62.0
SR		R	55.0	57.0	61.0	63.0	65.0
WL	Bealey Avenue (West)	L	139.0	140.0	140.0	140.0	141.0
WT		T	137.0	137.0	137.0	138.0	139.0
WR		R	144.0	145.0	147.0	152.0	159.0
All Movements		All	134.0	134.0	135.0	136.0	137.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Colombo Street (North)	L	61.0	61.0	61.0	62.0	63.0
NT		T	61.0	62.0	63.0	65.0	68.0
NR		R	65.0	66.8	67.0	69.0	72.0
EL	Bealey Avenue (East)	L	129.0	130.0	130.0	131.0	131.0
ET		T	127.0	127.0	127.0	128.0	128.0
ER		R	136.0	140.0	190.0	604.0	1252.1
SL	Colombo Street (South)	L	35.0	35.0	35.0	35.0	35.0
ST		T	33.0	34.0	34.0	35.0	36.0
SR		R	37.0	38.0	38.0	39.0	40.0
WL	Bealey Avenue (West)	L	134.0	134.0	135.0	135.0	135.0
WT		T	131.0	131.0	132.0	132.0	132.0
WR		R	137.0	138.0	138.0	140.0	141.0
All Movements		All	95.0	97.0	97.0	103.0	112.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Colombo Street (North)	L	106.0	107.0	106.0	107.7	119.0
NT		T	110.0	112.0	113.0	117.0	147.0
NR		R	116.0	119.0	118.0	123.0	144.0
EL	Bealey Avenue (East)	L	151.0	152.0	154.0	155.0	153.0
ET		T	153.0	153.0	154.0	155.0	156.0
ER		R	172.0	198.0	579.0	1768.0	2569.0
SL	Colombo Street (South)	L	80.0	80.0	82.0	82.0	82.0
ST		T	81.0	82.0	84.0	85.0	88.0
SR		R	86.0	87.0	87.6	90.0	92.0
WL	Bealey Avenue (West)	L	157.0	156.0	157.0	156.1	158.0
WT		T	156.0	157.0	157.0	158.0	159.0
WR		R	165.0	166.0	172.0	178.0	185.0
All Movements		All	154.0	156.0	158.0	159.0	161.0

Method 2 Existing Rule							
Mean Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Colombo Street (North)	L	81.7	82.1	82.8	81.1	80.6
NT		T	85.0	86.2	86.3	88.0	89.7
NR		R	88.3	91.9	90.3	91.4	93.1
EL	Bealey Avenue (East)	L	141.2	141.9	143.1	144.4	145.8
ET		T	137.1	137.1	137.1	136.9	136.9
ER		R	154.5	161.1	181.1	307.3	935.3
SL	Colombo Street (South)	L	57.0	56.9	56.8	56.9	56.3
ST		T	55.3	56.9	57.4	57.3	59.5
SR		R	59.8	60.5	60.7	61.0	62.0
WL	Bealey Avenue (West)	L	144.8	145.7	146.2	146.3	147.0
WT		T	141.0	141.1	140.7	140.6	140.3
WR		R	148.2	148.4	149.4	150.0	150.4
All Movements		All	128.4	129.2	131.2	145.6	252.2
Median Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Colombo Street (North)	L	76.0	77.0	78.0	74.0	74.0
NT		T	83.0	85.0	85.0	86.0	90.0
NR		R	84.0	91.0	89.0	89.0	93.0
EL	Bealey Avenue (East)	L	138.0	138.0	139.0	140.0	141.0
ET		T	133.0	133.0	133.0	133.0	132.0
ER		R	150.0	157.0	173.0	263.0	1021.0
SL	Colombo Street (South)	L	52.0	53.0	52.0	52.0	51.0
ST		T	52.0	55.0	55.0	55.0	59.0
SR		R	57.0	57.0	59.0	58.0	60.0
WL	Bealey Avenue (West)	L	142.0	143.0	143.0	143.0	144.0
WT		T	137.0	137.0	137.0	137.0	136.0
WR		R	145.0	145.0	146.0	147.0	148.0
All Movements		All	134.0	135.0	135.0	136.0	137.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Colombo Street (North)	L	63.0	63.0	63.0	63.0	63.0
NT		T	62.0	62.0	62.0	63.0	64.0
NR		R	67.0	66.0	67.0	67.0	68.0
EL	Bealey Avenue (East)	L	132.0	132.0	132.0	133.0	133.0
ET		T	127.0	127.0	127.0	127.0	127.0
ER		R	136.0	137.0	144.0	171.0	427.0
SL	Colombo Street (South)	L	37.0	37.0	37.0	37.0	37.0
ST		T	33.0	34.0	34.0	34.0	35.0
SR		R	37.0	38.0	38.0	38.0	39.0
WL	Bealey Avenue (West)	L	136.0	137.0	137.0	137.0	137.0
WT		T	131.0	131.0	131.0	131.0	131.0
WR		R	138.0	138.0	138.0	138.0	138.0
All Movements		All	99.0	97.0	94.0	93.0	90.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Colombo Street (North)	L	108.0	107.0	108.0	106.0	106.0
NT		T	110.0	112.0	112.0	113.0	114.0
NR		R	115.1	119.2	116.0	117.0	118.0
EL	Bealey Avenue (East)	L	154.0	156.0	157.0	159.1	161.0
ET		T	154.0	153.0	153.0	153.0	153.0
ER		R	176.0	184.0	219.0	471.0	1426.0
SL	Colombo Street (South)	L	83.0	81.0	82.0	81.0	81.0
ST		T	81.0	82.0	83.0	83.0	83.0
SR		R	87.0	87.0	86.0	86.0	86.0
WL	Bealey Avenue (West)	L	159.0	160.0	162.0	161.0	162.0
WT		T	156.0	157.0	156.0	156.0	155.0
WR		R	167.0	167.0	168.0	169.0	169.0
All Movements		All	154.0	155.0	158.0	163.0	193.0

Method 2 Changed Rule							
Mean Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Colombo Street (North)	L	80.5	81.2	81.4	80.1	79.5
NT		T	85.0	86.2	86.3	87.9	89.8
NR		R	88.2	91.7	90.3	91.6	93.3
EL	Bealey Avenue (East)	L	138.4	138.3	138.1	138.5	137.6
ET		T	137.1	137.1	137.2	137.0	137.1
ER		R	158.2	169.2	214.2	508.2	1216.7
SL	Colombo Street (South)	L	55.4	55.3	55.3	55.4	55.0
ST		T	55.3	57.1	57.5	57.3	59.6
SR		R	59.8	60.5	60.7	61.0	62.1
WL	Bealey Avenue (West)	L	142.0	142.1	142.1	142.3	142.5
WT		T	141.0	141.1	140.7	140.7	140.3
WR		R	148.1	148.4	149.5	150.1	150.4
All Movements		All	128.2	129.3	133.5	166.3	294.2
Median Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Colombo Street (North)	L	75.0	76.0	76.0	74.0	74.0
NT		T	83.0	85.0	85.0	86.0	90.0
NR		R	84.0	91.0	89.0	89.0	93.0
EL	Bealey Avenue (East)	L	134.0	134.0	134.0	134.0	134.0
ET		T	133.0	133.0	133.0	133.0	132.0
ER		R	154.0	165.0	201.0	484.0	1332.0
SL	Colombo Street (South)	L	50.0	51.0	51.0	50.0	51.0
ST		T	52.0	56.0	55.0	55.0	59.0
SR		R	57.0	57.0	59.0	58.0	60.0
WL	Bealey Avenue (West)	L	139.0	140.0	139.0	139.0	139.0
WT		T	137.0	137.0	137.0	137.0	136.0
WR		R	145.0	145.0	146.0	147.0	148.0
All Movements		All	134.0	134.0	135.0	135.0	136.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Colombo Street (North)	L	61.0	61.0	61.0	61.0	61.0
NT		T	62.0	62.0	62.0	63.0	64.0
NR		R	67.0	66.8	67.0	67.0	68.5
EL	Bealey Avenue (East)	L	129.3	130.0	130.0	130.0	129.0
ET		T	127.0	127.0	127.0	127.0	127.0
ER		R	137.0	140.0	154.0	228.0	610.0
SL	Colombo Street (South)	L	35.0	35.0	35.0	35.0	35.0
ST		T	33.0	34.0	34.0	34.0	35.0
SR		R	37.0	38.0	38.0	38.0	39.0
WL	Bealey Avenue (West)	L	134.0	134.0	134.0	134.0	134.0
WT		T	131.0	131.0	131.0	131.0	131.0
WR		R	138.0	138.0	138.0	138.0	138.0
All Movements		All	98.0	97.0	94.0	93.0	90.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Colombo Street (North)	L	107.0	107.0	107.5	105.0	105.0
NT		T	110.0	112.0	112.0	113.0	114.0
NR		R	115.0	119.0	116.0	118.0	118.0
EL	Bealey Avenue (East)	L	152.8	152.0	152.0	153.0	151.0
ET		T	153.0	153.0	154.0	153.0	153.0
ER		R	181.0	198.0	282.0	794.0	1770.0
SL	Colombo Street (South)	L	82.0	80.0	81.0	80.0	80.0
ST		T	81.0	82.0	83.0	83.0	83.0
SR		R	87.0	87.0	86.0	86.0	86.0
WL	Bealey Avenue (West)	L	156.0	156.0	157.0	157.0	157.0
WT		T	156.0	157.0	156.0	156.0	155.0
WR		R	166.8	166.0	169.0	169.0	169.0
All Movements		All	154.0	156.0	159.0	163.0	199.0

A6.7 Full Queue Length Analysis Results

Method 1							
Existing Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Colombo Street (North)	L	1.1	1.1	1.1	1.3	1.4
N2		TR	1.4	1.7	1.9	2.2	2.5
E1	Bealey Avenue (East)	L	1.1	1.1	1.2	1.3	1.3
E2		T	1.6	1.9	2.2	2.6	2.9
E3		T	1.3	1.5	1.7	2.2	2.7
E4		T	1.1	1.3	3.6	31.4	73.4
E5		R	1.3	1.7	3.8	5.3	5.5
S1	Colombo Street (South)	L	1.3	1.5	1.7	1.9	2.2
S2		TR	1.5	1.7	1.9	2.2	2.5
W1	Bealey Avenue (West)	L	1.1	1.2	1.2	1.3	1.4
W2		T	1.7	2.1	2.4	2.7	3.1
W3		T	1.3	1.5	1.7	2.1	2.4
W4		T	1.2	1.4	1.5	1.7	2.1
W5		R	1.1	1.2	1.3	1.5	1.8
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Colombo Street (North)	L	1.2	1.3	1.4	1.7	2.0
N2		TR	2.1	2.7	3.3	3.9	4.5
E1	Bealey Avenue (East)	L	1.2	1.4	1.6	1.8	2.1
E2		T	2.8	3.5	4.1	4.9	5.6
E3		T	1.9	2.3	3.3	4.5	5.8
E4		T	1.5	1.9	5.5	36.7	80.2
E5		R	2.0	2.9	5.4	6.7	6.7
S1	Colombo Street (South)	L	1.8	2.1	2.8	3.3	4.2
S2		TR	2.2	2.7	3.3	4.0	4.8
W1	Bealey Avenue (West)	L	1.3	1.5	1.7	1.8	2.0
W2		T	2.8	3.7	4.3	5.1	5.9
W3		T	2.0	2.5	3.0	3.8	4.6
W4		T	1.7	2.1	2.6	3.0	3.7
W5		R	1.3	1.5	1.8	2.4	3.1
Changed Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Colombo Street (North)	L	1.1	1.1	1.2	1.3	1.4
N2		TR	1.4	1.7	1.9	2.2	2.5
E1	Bealey Avenue (East)	L	1.1	1.1	1.1	1.3	1.3
E2		T	1.6	1.9	2.3	2.6	2.9
E3		T	1.3	1.5	1.7	2.2	2.7
E4		T	1.1	1.3	7.0	44.4	87.7
E5		R	1.4	1.9	4.6	5.4	5.6
S1	Colombo Street (South)	L	1.3	1.5	1.7	1.9	2.1
S2		TR	1.5	1.7	1.9	2.2	2.5
W1	Bealey Avenue (West)	L	1.2	1.2	1.2	1.3	1.3
W2		T	1.7	2.1	2.4	2.7	3.1
W3		T	1.3	1.5	1.7	2.1	2.4
W4		T	1.2	1.4	1.6	1.7	2.1
W5		R	1.1	1.2	1.3	1.5	1.8
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Colombo Street (North)	L	1.2	1.3	1.4	1.7	2.0
N2		TR	2.1	2.7	3.3	3.9	4.5
E1	Bealey Avenue (East)	L	1.2	1.3	1.5	1.7	1.9
E2		T	2.8	3.4	4.2	4.9	5.6
E3		T	1.9	2.4	3.4	4.5	5.8
E4		T	1.5	2.0	9.4	49.5	94.4
E5		R	2.1	3.2	6.0	6.7	6.8
S1	Colombo Street (South)	L	1.8	2.1	2.8	3.2	4.0
S2		TR	2.2	2.7	3.3	4.1	4.8
W1	Bealey Avenue (West)	L	1.4	1.5	1.6	1.7	1.9
W2		T	2.9	3.7	4.4	5.0	5.9
W3		T	2.0	2.6	3.1	3.7	4.6
W4		T	1.7	2.1	2.5	3.0	3.7
W5		R	1.3	1.5	1.8	2.4	3.0

Method 2							
Existing Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Colombo Street (North)	L	1.1	1.1	1.1	1.1	1.1
N2		TR	1.6	1.7	1.7	1.8	1.9
E1	Bealey Avenue (East)	L	1.1	1.1	1.1	1.1	1.1
E2		T	2.0	1.9	1.8	1.8	1.6
E3		T	1.5	1.5	1.4	1.4	1.3
E4		T	1.3	1.3	1.7	7.7	32.2
E5		R	1.2	1.7	2.8	4.2	4.6
S1	Colombo Street (South)	L	1.5	1.5	1.5	1.4	1.3
S2		TR	1.6	1.7	1.7	1.9	2.1
W1	Bealey Avenue (West)	L	1.2	1.2	1.2	1.2	1.1
W2		T	2.1	2.1	1.9	1.8	1.6
W3		T	1.6	1.5	1.4	1.4	1.3
W4		T	1.4	1.4	1.3	1.3	1.2
W5		R	1.1	1.2	1.3	1.5	1.8
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Colombo Street (North)	L	1.3	1.3	1.3	1.2	1.2
N2		TR	2.5	2.7	2.8	3.0	3.3
E1	Bealey Avenue (East)	L	1.4	1.4	1.3	1.4	1.2
E2		T	3.6	3.5	3.2	3.0	2.7
E3		T	2.5	2.3	2.3	2.2	1.9
E4		T	2.0	1.9	2.8	11.2	67.0
E5		R	1.7	2.9	4.5	5.8	6.1
S1	Colombo Street (South)	L	2.3	2.1	2.2	2.1	1.8
S2		TR	2.4	2.7	3.0	3.3	3.9
W1	Bealey Avenue (West)	L	1.4	1.5	1.5	1.5	1.4
W2		T	3.8	3.7	3.4	3.1	2.8
W3		T	2.6	2.5	2.2	2.2	1.8
W4		T	2.1	2.1	1.9	1.8	1.6
W5		R	1.2	1.5	2.0	2.5	3.5
Changed Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Colombo Street (North)	L	1.1	1.1	1.2	1.1	1.1
N2		TR	1.6	1.7	1.7	1.8	1.9
E1	Bealey Avenue (East)	L	1.1	1.1	1.1	1.2	1.0
E2		T	2.0	1.9	1.9	1.8	1.6
E3		T	1.5	1.5	1.4	1.4	1.3
E4		T	1.3	1.3	2.6	17.8	41.8
E5		R	1.3	1.9	3.6	4.8	4.8
S1	Colombo Street (South)	L	1.6	1.5	1.5	1.5	1.3
S2		TR	1.6	1.7	1.7	1.9	2.1
W1	Bealey Avenue (West)	L	1.2	1.2	1.2	1.2	1.1
W2		T	2.1	2.1	1.9	1.8	1.6
W3		T	1.6	1.5	1.5	1.4	1.3
W4		T	1.4	1.4	1.3	1.3	1.2
W5		R	1.1	1.2	1.3	1.5	1.8
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Colombo Street (North)	L	1.3	1.3	1.3	1.3	1.2
N2		TR	2.5	2.7	2.8	3.0	3.3
E1	Bealey Avenue (East)	L	1.4	1.3	1.3	1.4	1.2
E2		T	3.6	3.4	3.3	3.2	2.7
E3		T	2.5	2.4	2.3	2.3	1.8
E4		T	2.0	2.0	4.2	24.6	90.9
E5		R	1.7	3.2	5.3	6.2	6.2
S1	Colombo Street (South)	L	2.3	2.1	2.2	2.1	1.8
S2		TR	2.4	2.7	3.0	3.3	3.9
W1	Bealey Avenue (West)	L	1.4	1.5	1.4	1.4	1.4
W2		T	3.7	3.7	3.3	3.1	2.7
W3		T	2.7	2.6	2.3	2.1	1.8
W4		T	2.2	2.1	1.9	1.8	1.6
W5		R	1.2	1.5	2.0	2.5	3.5

APPENDIX A7

Intersection 5 – Main North Road/Prestons Road

Full Data

Table of Contents

A7.1 Approach Photos

Figure A7.1.1 - Prestons Road East Approach

Figure A7.1.2 - Main North Road North Approach

Figure A7.1.3 - Main North Road South Approach

A7.2 Surveyed Traffic Volume Data

Intersection 5: Main North Road/Prestons Road

Survey Date Friday, 29 September 2006

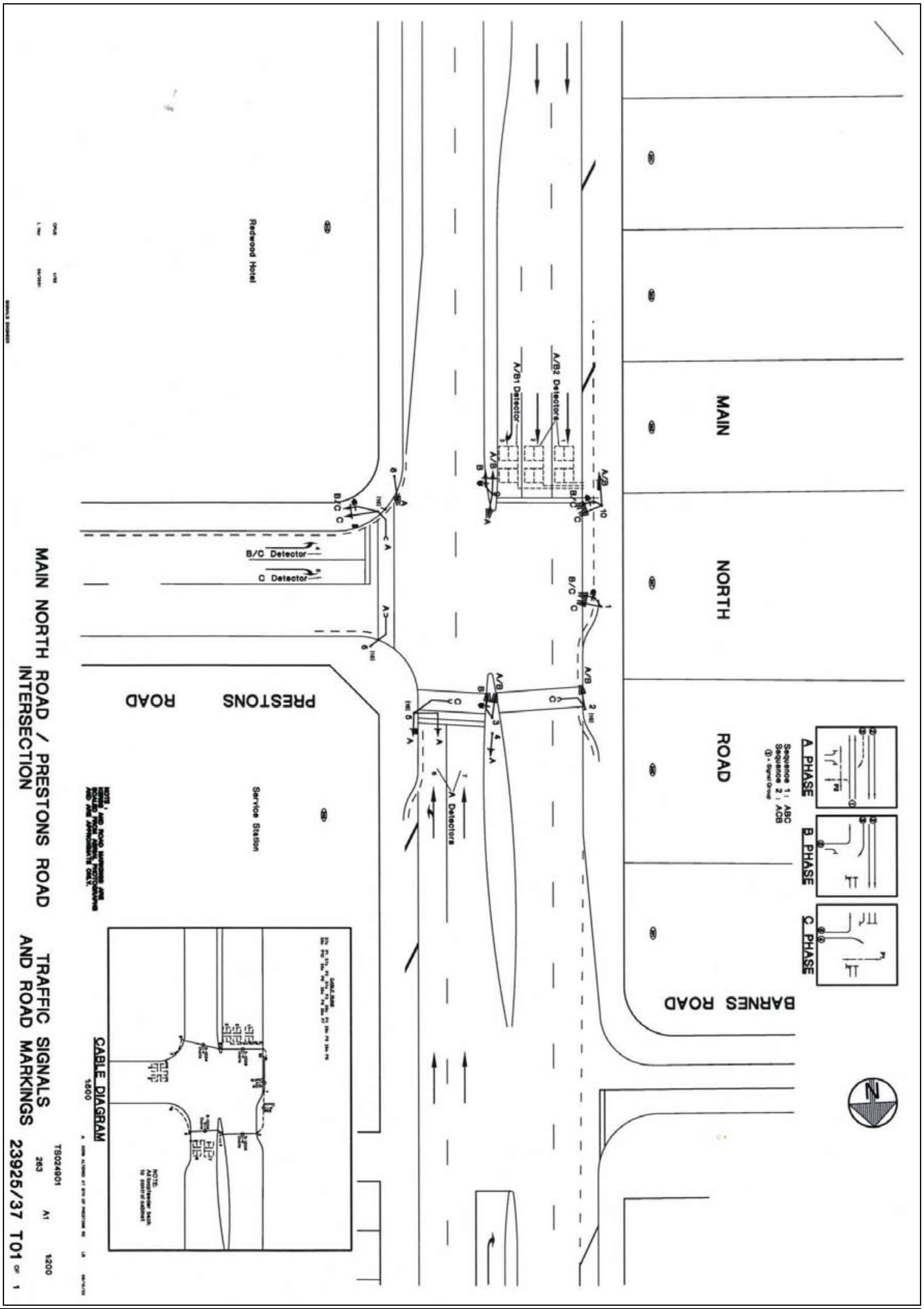
Light Vehicles			Prestons		Main North (North)		Main North (South)		TOTAL
			L	R	T	L	T	R	
3:30	-	3:45	23	20	175	16	249	48	531
3:45	-	4:00	20	25	205	31	274	31	586
4:00	-	4:15	15	24	127	16	289	28	499
4:15	-	4:30	21	33	240	43	222	25	584
4:30	-	4:45	30	18	220	34	318	45	665
4:45	-	5:00	16	26	160	34	235	26	497

Heavy Vehicles			Prestons		Main North (North)		Main North (South)		TOTAL
			L	R	T	L	T	R	
3:30	-	3:45	1	1	4	2	1	1	10
3:45	-	4:00	2	1	7	1	2	1	14
4:00	-	4:15	1	1	5	2	2	0	11
4:15	-	4:30	0	2	3	1	0	1	7
4:30	-	4:45	0	0	2	2	0	0	4
4:45	-	5:00	0	0	2	1	1	2	6

Total	Prestons		Main North (North)		Main North (South)	
(3:30pm - 5:00pm)	L	R	T	L	T	R
Light	125	146	1,127	174	1,587	203
Heavy	4	5	23	9	6	5

Peak Hour	Prestons		Main North (North)		Main North (South)	
(3:45pm - 4:45pm)	L	R	T	L	T	R
Light	86	100	792	124	1,103	129
Heavy	3	4	17	6	4	2

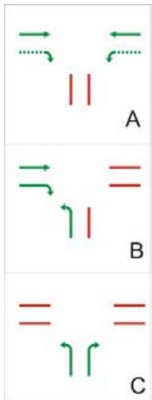
A7.3 Traffic Signal Plan



A7.4 Observed and Modelled Signal Timings

Intersection 5 Main North Road/Prestons Road (SCATS ID = 263)

Traffic Count Day		Friday 29 September, 2006		
Observed Signal Day		Thursday 21 September, 2006		
Observed Time Period		3:30pm to 5:00pm		
Observed Phase Timings				
Phase	Count	Minimum (s)	Maximum (s)	Average (s)
A	43	42	107	72
B	38	12	33	25
C	43	27	41	32
Cycle	-	-	-	129
Modelled Phase Timings				
A	-	-	-	70
B	-	-	-	20
C	-	-	-	25
Cycle	-	-	-	115



A7.5 Results Summary

A7.5.1 Journey Times Method 1

Figure A7.5.1 to Figure A7.5.3 present journey time comparisons for the right and left turn movements off Main North Road and for the average journey time for all movements through the intersection.

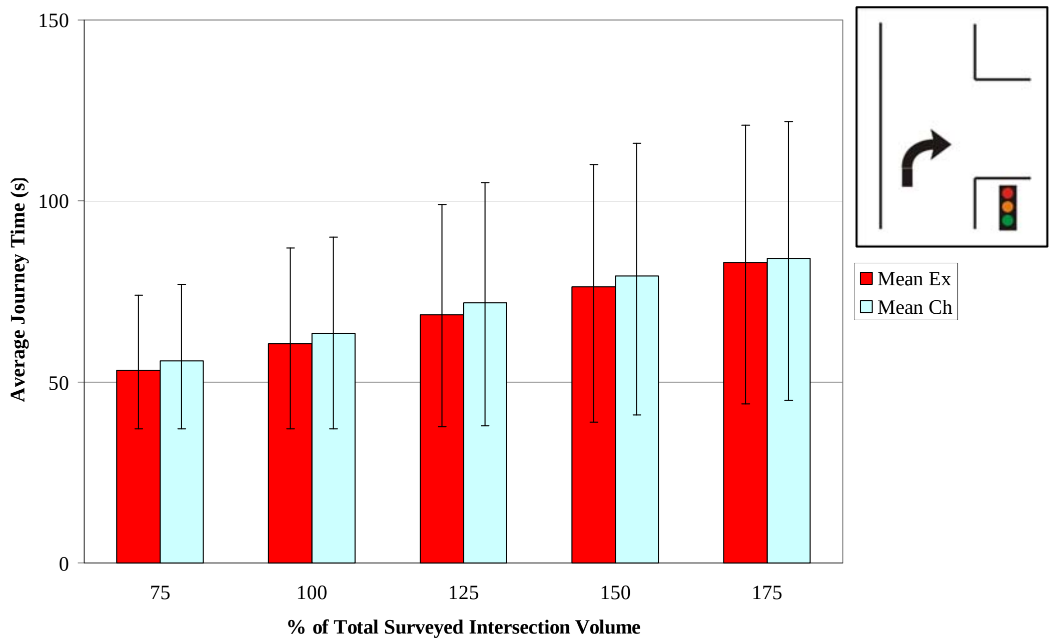


Figure A7.5.1 - Intersection 5, M1, Main North Road (South) Right Turn Journey Time Comparison

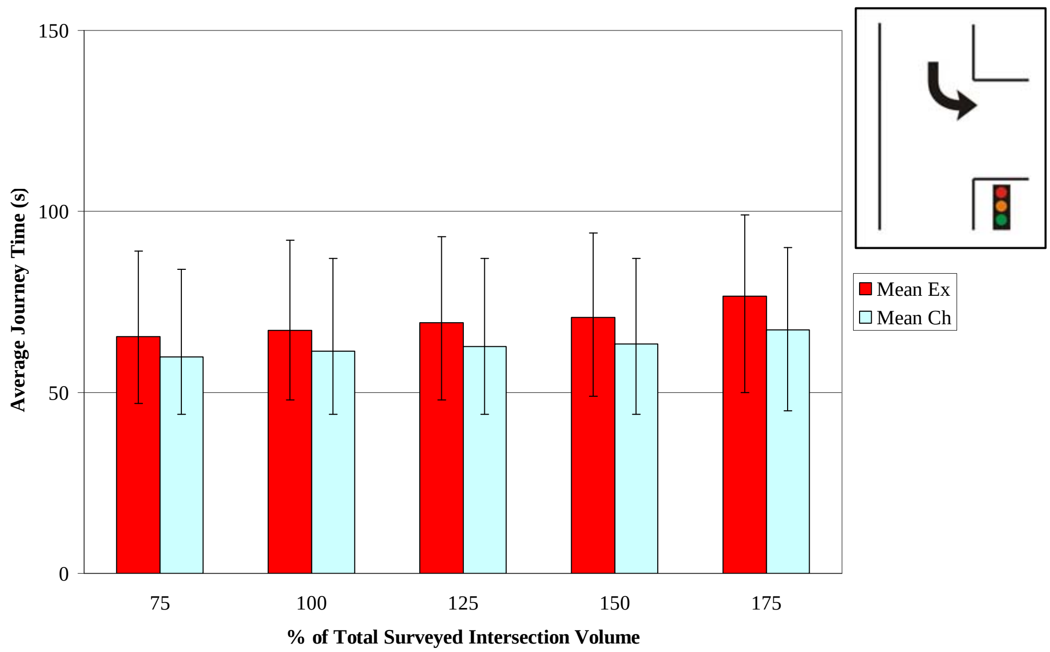


Figure A7.5.2 - Intersection 5, M1, Main North Road (North) Left Turn Journey Time Comparison

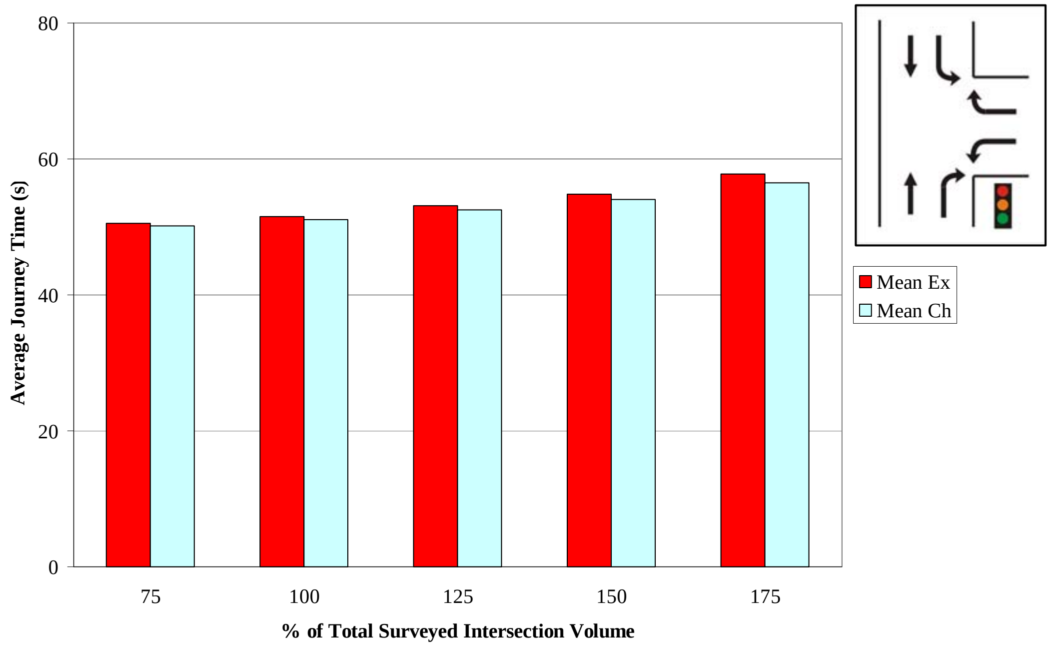


Figure A7.5.3 - Intersection 5, M1, Total Intersection Journey Time Comparison

A7.5.2 Journey Times Method 2

Figure A7.5.4 to Figure A7.5.7 present journey time comparisons for the right and left turn movements off Main North Road and for the overall journey time for all movements through the intersection.

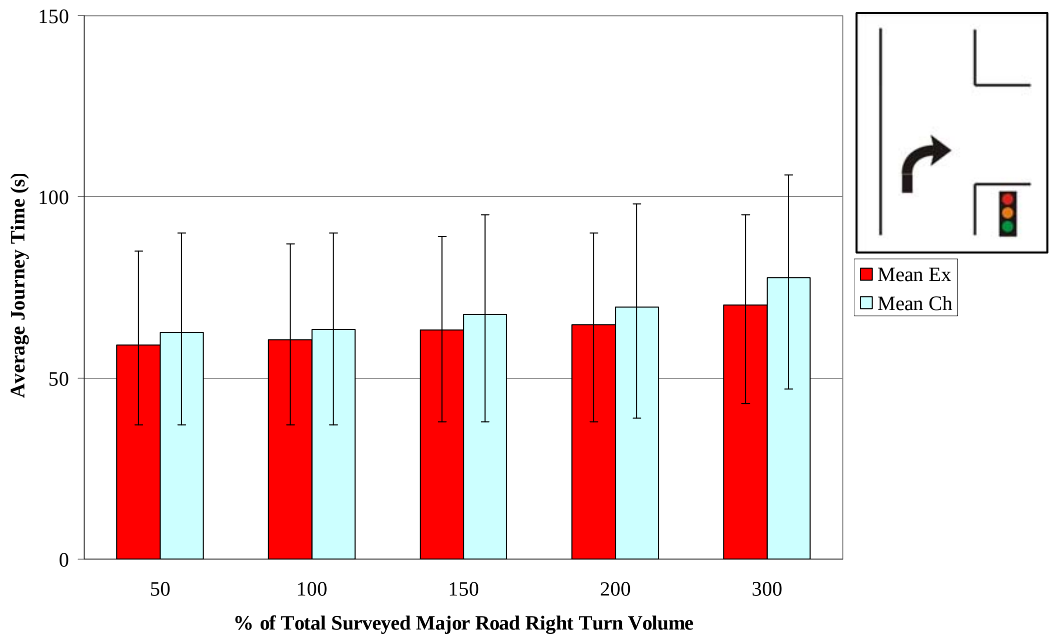


Figure A7.5.4 - Intersection 5, M2, Main North Road (South) Right Turn Journey Time Comparison

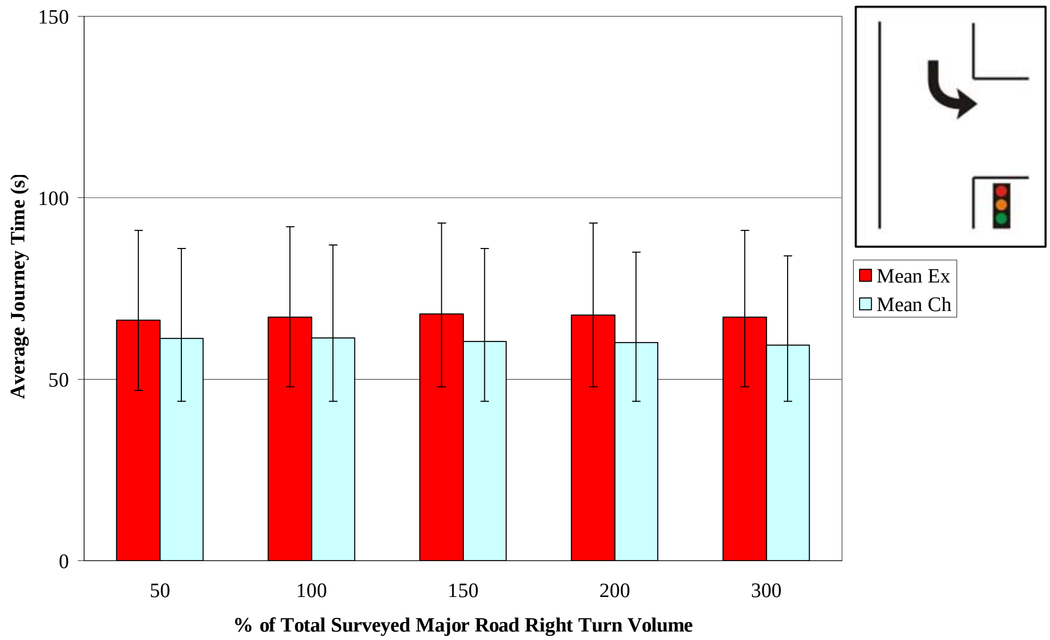


Figure A7.5.5 - Intersection 5, M2, Main North Road (North) Left Turn Journey Time Comparison

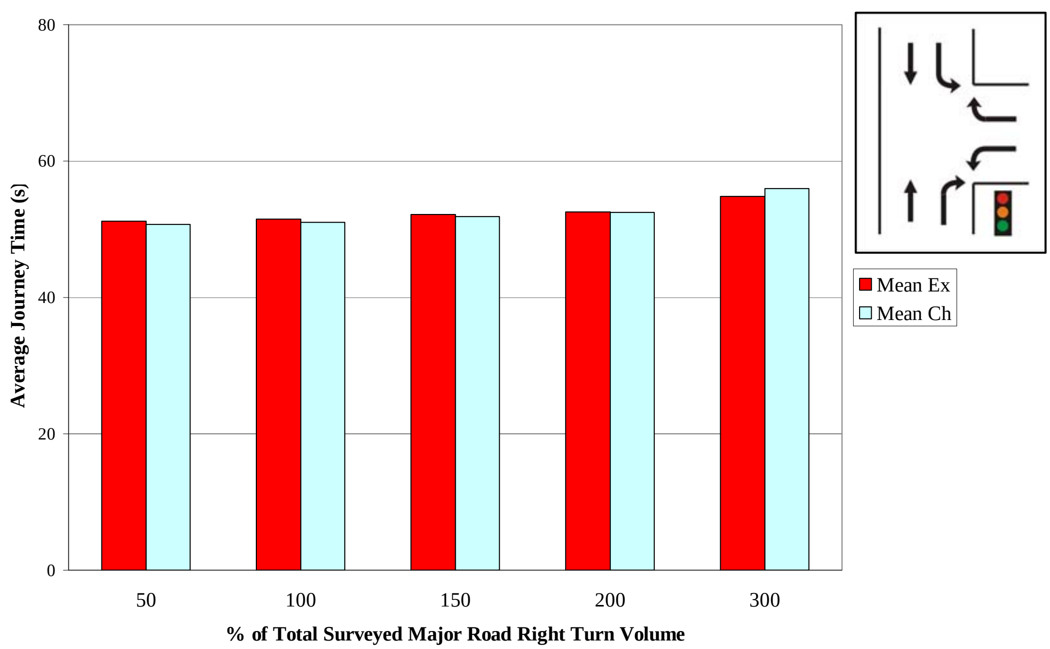


Figure A7.5.6 - Intersection 5, M2, Total Intersection Journey Time Comparison

Table A7.5.1 summarises the average journey times for all movements for each volume scenario.

Table A7.5.1 - Intersection 5, M2, Average Journey Time Comparison

Approach	Mvt	Average Journey Time (seconds/vehicle) for Various % Scenarios									
		50%		100%		150%		200%		300%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Main North Road (North)	L	66	61	67	61	68	60	68	60	67	59
	T	58	58	59	58	58	57	58	57	58	57
Prestons Road (East)	L	60	60	59	59	60	60	59	59	61	60
	R	78	78	76	76	78	78	75	75	78	77
Main North Road (South)	T	40	40	40	40	40	41	41	41	42	43
	R	59	63	61	63	63	68	65	69	70	78
Total	All	51	51	52	51	52	52	53	52	55	56

It is evident from the analysis that with the changed rule, as expected, that the right turn journey increases and the left turn journey time decreases. Table A7.5.2 presents a summary of the increase or decrease for these two movements as a result of the rule change to nearside priority.

Table A7.5.2 - Intersection 5, M, Right and Left Turn Journey Time Changes

Movement	Change in Journey Time (seconds/vehicle) for Various % Scenarios				
	75%	100%	125%	150%	175%
Main North Rd Right Turn	3	3	4	5	8
Main North Rd Left Turn	-5	-6	-8	-7	-8

Table A7.5.2 shows that the increase in right turn journey time as a result of the rule change to nearside priority is very slightly less than the corresponding decrease to the left turn journey time. Overall there is very little difference between the average journey times through the intersection under each rule.

A7.5.3 Queue Lengths Method 1

Figure A7.5.7 to Figure A7.5.9 present queue length comparisons for right and left turns off Main North Road as well as for the longest queue in any lane on the Prestons Road approach. It should be noted that the left turn off Main North Road uses a shared through and left lane.

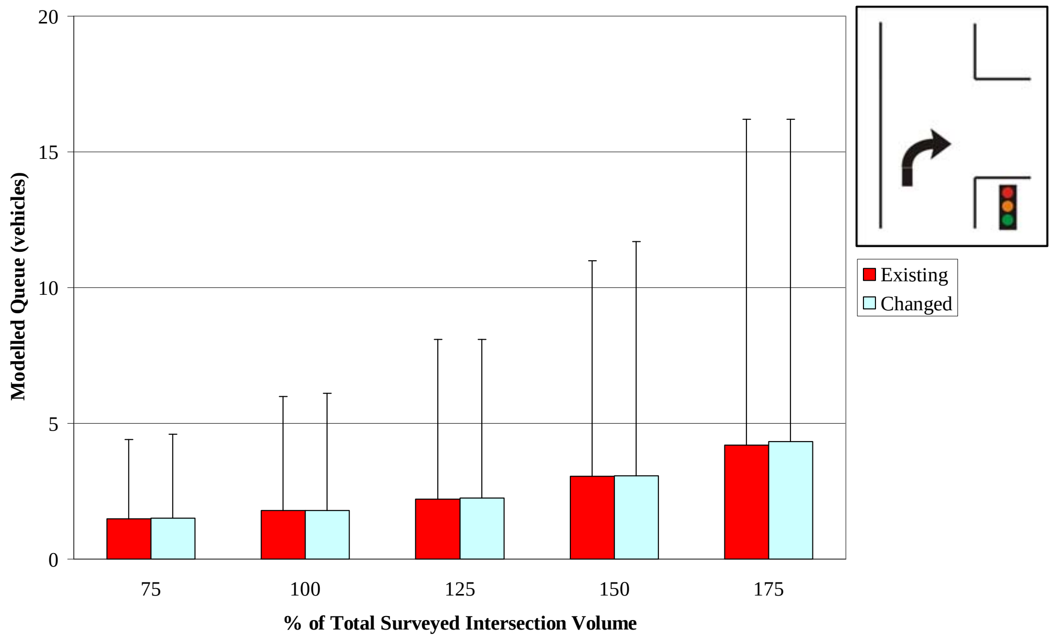


Figure A7.5.7 - Intersection 5, M1, Main North Road (South) Right Turn Queue Comparison

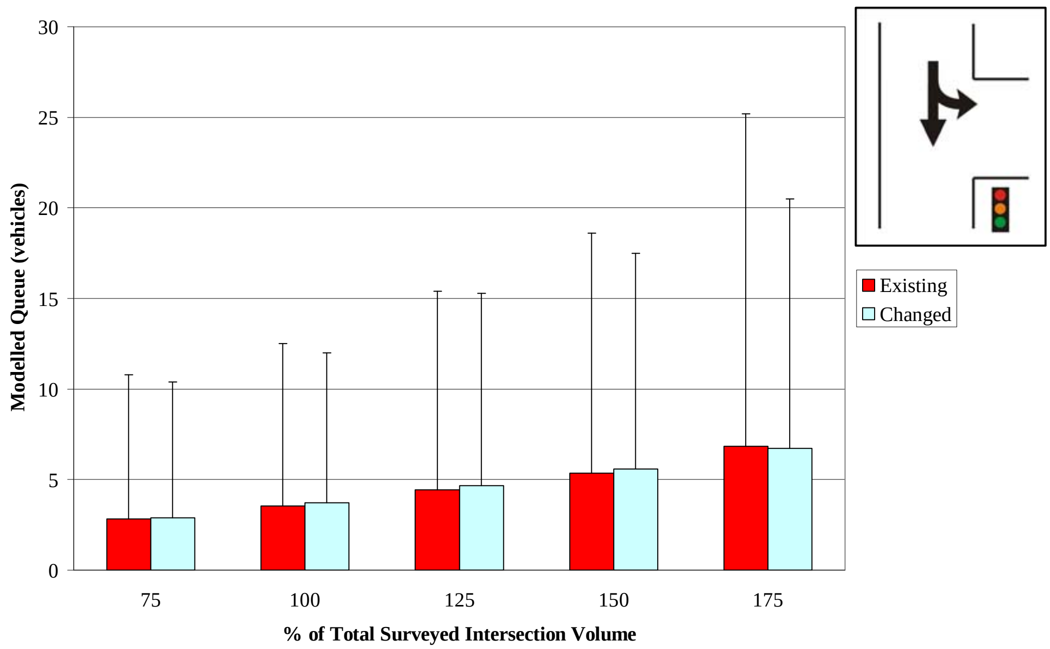


Figure A7.5.8 - Intersection 5, M1, Main North Road (North) Shared Through & Left Turn Queue Comparison

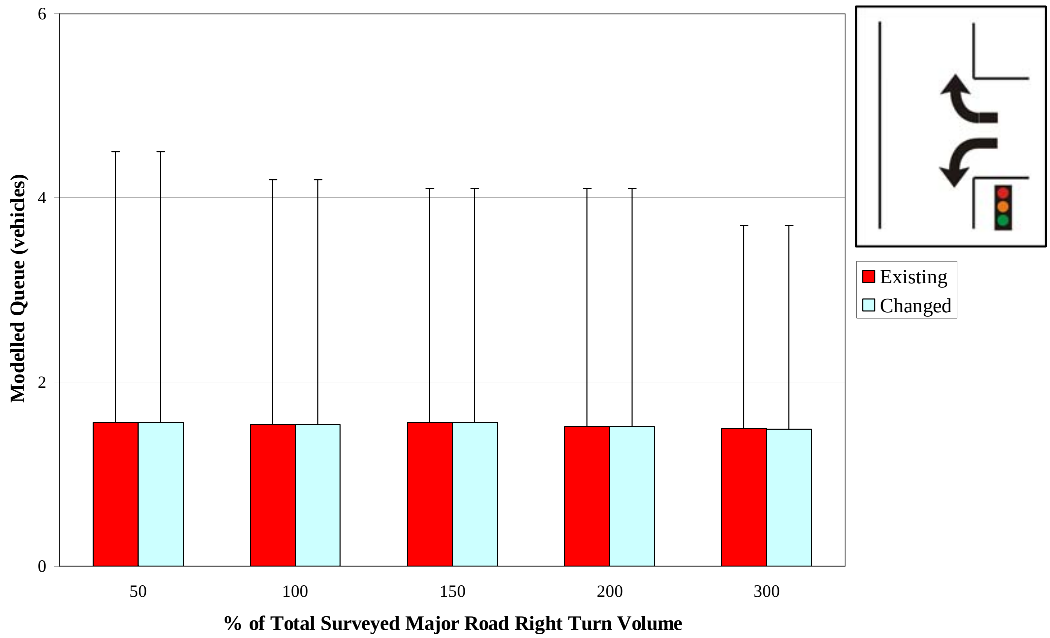


Figure A7.5.9 - Intersection 5, M1, Prestons Road (East) Queue Comparison

A7.5.4 Queue Lengths Method 2

Figure A7.5.10 to Figure A7.5.12 present queue length comparisons for right and left turns off Main North Road as well as for the longest queue in any lane on the Prestons Road approach. It should be noted that the left turn off Main North Road uses a shared through and left lane.

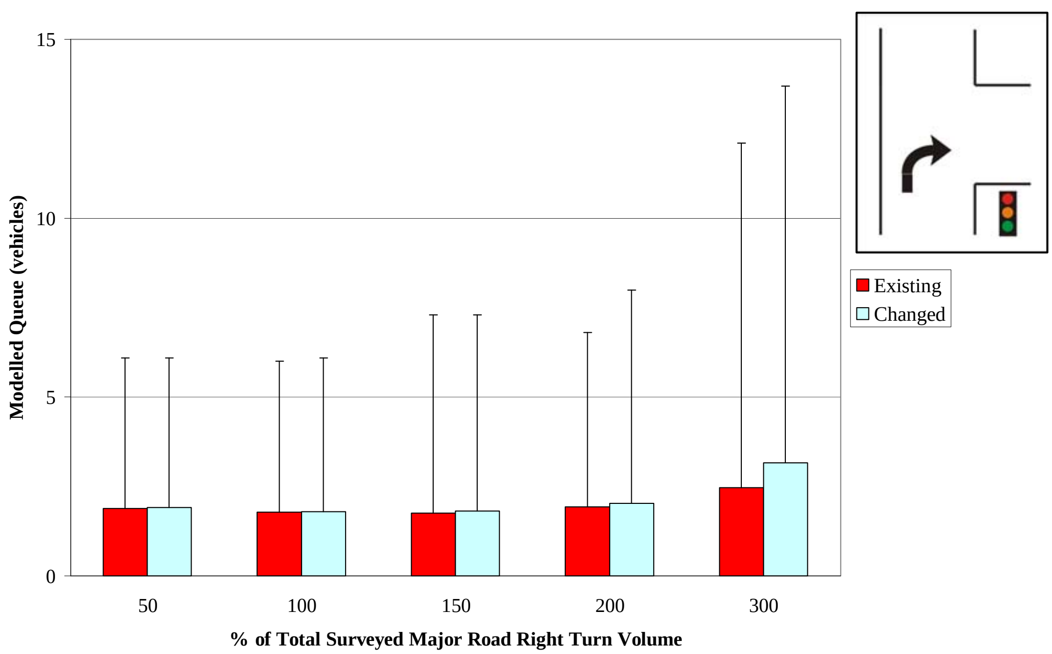


Figure A7.5.10 - Intersection 5, M2, Main North Road (South) Right Turn Queue Comparison

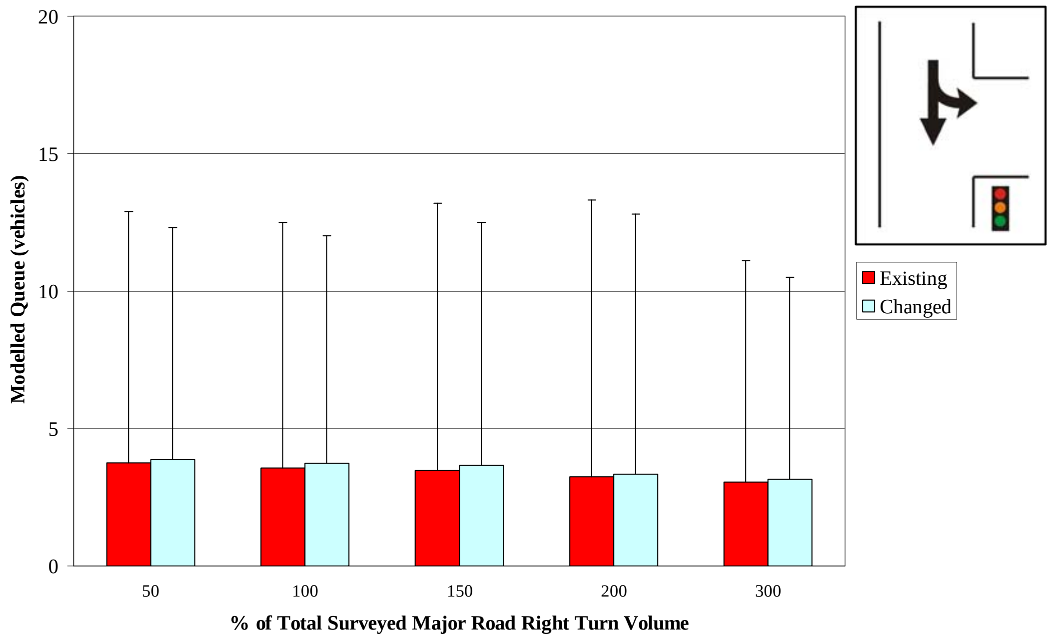


Figure A7.5.11 - Intersection 5, M2, Main North Road (North) Shared Through & Left Turn Queue Comparison

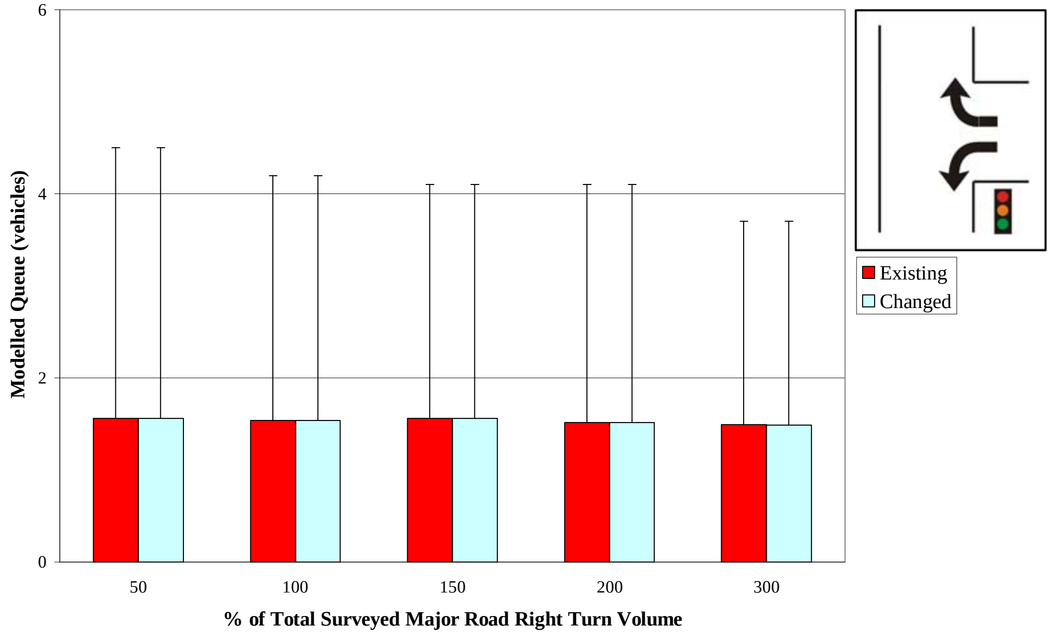


Figure A7.5.12 - Intersection 5, M2, Prestons Road (East) Queue Comparison

Table A7.5.3 summarises the average queue lengths for all movements for each volume scenario.

Table A7.5.3 - Intersection 5 M2 Average Queue Comparison

Approach	Mvt	Average Queue Length (vehicles) for Various % Scenarios									
		50%		100%		150%		200%		300%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Main North Road (North)	LT	3.7	3.9	3.6	3.7	3.5	3.7	3.2	3.3	3.1	3.2
	T	3.6	3.5	3.5	3.5	3.4	3.3	3.3	3.2	3.0	3.0
Prestons Road (East)	L	1.6	1.6	1.5	1.5	1.6	1.6	1.5	1.5	1.5	1.5
	R	2.1	2.1	1.9	1.9	1.9	2.0	1.8	1.8	1.8	1.8
Main North Road (South)	T	3.1	3.0	2.9	2.9	2.7	2.7	2.6	2.7	2.6	2.7
	T	1.9	1.9	1.8	1.8	1.8	1.8	1.9	2.0	2.5	3.2
	R	1.3	1.4	1.8	1.9	2.3	2.5	2.8	3.1	3.9	4.4

Table A7.5.3 illustrates that there is very little difference in any modelled queue lengths for any movements at the intersection.

A7.6 Full Journey Time Analysis Results

Method 1 Existing Rule							
Mean Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Main North Road (North)	L	65.5	67.2	69.2	70.7	76.6
NT		T	57.2	58.6	60.3	62.1	65.8
EL	Prestons Road (East)	L	60.1	59.5	60.3	61.5	61.3
ER		R	78.8	76.5	80.0	78.2	78.4
ST	Main North Road (South)	T	40.2	40.5	41.1	42.1	44.4
SR		R	53.3	60.6	68.6	76.3	83.0
All Movements		All	50.5	51.5	53.2	54.8	57.8
Median Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Main North Road (North)	L	59.0	62.0	67.0	69.0	78.0
NT		T	47.0	51.0	54.0	58.0	64.0
EL	Prestons Road (East)	L	51.0	50.0	51.0	54.0	54.0
ER		R	76.0	74.0	79.0	76.0	77.0
ST	Main North Road (South)	T	35.0	35.0	35.0	35.0	39.0
SR		R	47.0	55.0	66.0	75.0	82.0
All Movements		All	42.0	42.0	44.0	47.0	51.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Main North Road (North)	L	47.0	48.0	48.0	49.0	50.0
NT		T	41.0	41.0	41.0	42.0	42.0
EL	Prestons Road (East)	L	37.0	37.0	37.0	37.0	37.0
ER		R	37.0	36.0	37.1	37.0	38.0
ST	Main North Road (South)	T	35.0	35.0	35.0	35.0	35.0
SR		R	37.0	37.0	37.6	39.0	44.0
All Movements		All	35.0	35.0	35.0	35.0	35.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Main North Road (North)	L	89.0	92.0	93.0	94.0	99.0
NT		T	82.0	84.0	85.0	87.0	91.0
EL	Prestons Road (East)	L	94.0	92.0	94.0	95.0	94.0
ER		R	122.0	118.0	121.0	119.0	119.0
ST	Main North Road (South)	T	52.0	53.0	54.0	56.0	60.0
SR		R	74.0	87.0	99.0	110.0	121.0
All Movements		All	72.0	75.0	78.0	81.0	86.0

Method 1 Changed Rule							
Mean Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Main North Road (North)	L	59.8	61.3	62.7	63.4	67.2
NT		T	56.5	57.7	58.9	60.4	62.7
EL	Prestons Road (East)	L	60.1	59.5	60.2	61.4	61.4
ER		R	78.8	76.5	79.9	78.1	79.1
ST	Main North Road (South)	T	40.2	40.5	41.1	42.2	44.7
SR		R	55.8	63.4	71.8	79.3	84.1
All Movements		All	50.1	51.1	52.6	54.0	56.5
Median Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Main North Road (North)	L	51.0	54.0	58.0	59.0	67.0
NT		T	46.0	49.0	52.0	55.0	60.0
EL	Prestons Road (East)	L	51.0	50.0	50.0	54.0	54.0
ER		R	76.0	74.0	79.0	76.0	78.0
ST	Main North Road (South)	T	35.0	35.0	35.0	35.0	39.0
SR		R	49.0	58.0	69.0	79.0	83.0
All Movements		All	42.0	42.0	43.0	45.0	49.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Main North Road (North)	L	44.0	44.0	44.0	44.0	45.0
NT		T	41.0	41.0	41.0	41.0	41.0
EL	Prestons Road (East)	L	37.0	37.0	37.0	37.0	37.0
ER		R	37.0	36.0	37.1	38.0	38.0
ST	Main North Road (South)	T	35.0	35.0	35.0	35.0	35.0
SR		R	37.0	37.0	38.0	41.0	45.0
All Movements		All	35.0	35.0	35.0	35.0	35.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Main North Road (North)	L	84.0	87.0	87.0	87.0	90.0
NT		T	82.0	83.0	84.0	85.0	87.0
EL	Prestons Road (East)	L	94.0	92.0	94.0	95.0	94.8
ER		R	122.0	118.0	121.0	119.0	120.0
ST	Main North Road (South)	T	52.0	53.0	54.0	56.0	60.0
SR		R	77.0	90.0	105.0	116.0	122.0
All Movements		All	71.0	74.0	77.0	79.0	82.0

Method 2 Existing Rule							
Mean Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Main North Road (North)	L	66.2	67.2	68.0	67.7	67.2
NT		T	58.4	58.6	58.4	58.2	57.8
EL	Prestons Road (East)	L	59.8	59.5	60.0	59.4	60.6
ER		R	78.3	76.5	78.3	75.4	77.5
ST	Main North Road (South)	T	40.5	40.5	40.5	40.7	41.9
SR		R	59.1	60.6	63.3	64.6	70.1
All Movements		All	51.2	51.5	52.1	52.5	54.8
Median Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Main North Road (North)	L	61.0	62.0	63.0	62.0	62.0
NT		T	50.0	51.0	50.0	49.0	48.0
EL	Prestons Road (East)	L	51.0	50.0	50.0	49.0	51.0
ER		R	78.0	74.0	76.0	70.0	74.0
ST	Main North Road (South)	T	35.0	35.0	35.0	35.0	35.0
SR		R	52.0	55.0	60.0	63.0	69.0
All Movements		All	42.0	42.0	43.0	43.0	46.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Main North Road (North)	L	47.0	48.0	48.0	48.0	48.0
NT		T	41.0	41.0	41.0	41.0	41.0
EL	Prestons Road (East)	L	37.0	37.0	37.0	37.0	37.0
ER		R	37.0	36.0	37.0	36.0	37.0
ST	Main North Road (South)	T	35.0	35.0	35.0	35.0	35.0
SR		R	37.0	37.0	38.0	38.0	43.0
All Movements		All	35.0	35.0	35.0	35.0	35.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Main North Road (North)	L	91.0	92.0	93.0	93.0	91.0
NT		T	84.0	84.0	84.0	84.0	83.0
EL	Prestons Road (East)	L	91.0	92.0	93.0	93.0	94.8
ER		R	119.0	118.0	119.0	119.0	120.0
ST	Main North Road (South)	T	53.0	53.0	53.0	53.0	55.0
SR		R	85.0	87.0	89.0	90.0	95.0
All Movements		All	74.0	75.0	77.0	77.0	81.0

Method 2 Changed Rule							
Mean Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Main North Road (North)	L	61.2	61.3	60.4	60.2	59.4
NT		T	57.6	57.7	57.3	57.0	56.7
EL	Prestons Road (East)	L	59.8	59.5	60.0	59.4	59.6
ER		R	78.3	76.5	78.3	75.4	76.9
ST	Main North Road (South)	T	40.5	40.5	40.6	40.9	43.0
SR		R	62.6	63.4	67.5	69.5	77.8
All Movements		All	50.7	51.1	51.8	52.5	55.9
Median Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Main North Road (North)	L	54.0	54.0	52.0	51.0	50.0
NT		T	49.0	49.0	48.0	47.0	47.0
EL	Prestons Road (East)	L	51.0	50.0	50.0	49.0	49.0
ER		R	78.0	74.0	76.0	70.0	73.0
ST	Main North Road (South)	T	35.0	35.0	35.0	35.0	36.0
SR		R	56.0	58.0	65.0	68.0	76.0
All Movements		All	42.0	42.0	42.0	43.0	46.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Main North Road (North)	L	44.0	44.0	44.0	44.0	44.0
NT		T	41.0	41.0	41.0	41.0	41.0
EL	Prestons Road (East)	L	37.0	37.0	37.0	37.0	37.0
ER		R	37.0	36.0	37.0	36.0	36.0
ST	Main North Road (South)	T	35.0	35.0	35.0	35.0	35.0
SR		R	37.0	37.0	38.0	39.0	47.0
All Movements		All	35.0	35.0	35.0	35.0	35.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Main North Road (North)	L	86.0	87.0	86.0	85.0	84.0
NT		T	83.0	83.0	83.0	83.0	82.0
EL	Prestons Road (East)	L	91.0	92.0	93.0	93.0	93.0
ER		R	119.0	118.0	119.0	119.0	120.0
ST	Main North Road (South)	T	53.0	53.0	53.0	53.0	57.0
SR		R	90.0	90.0	95.0	98.0	106.0
All Movements		All	73.0	74.0	76.0	77.0	83.0

A7.7 Full Queue Length Analysis Results

Method 1							
Existing Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Main North Road (North)	LT	2.8	3.6	4.5	5.4	6.8
N2		T	2.7	3.5	4.4	5.4	6.9
E1	Prestons Road	L	1.4	1.5	1.7	1.9	2.2
E2		R	1.7	1.9	2.4	2.6	2.9
S1	Main North Road (South)	T	2.3	2.9	3.6	4.1	5.0
S2		T	1.5	1.8	2.2	3.1	4.2
S3		R	1.3	1.8	2.3	2.8	3.4
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Main North Road (North)	LT	10.8	12.5	15.4	18.6	25.2
N2		T	8.0	10.9	12.7	14.8	20.0
E1	Prestons Road	L	3.4	4.2	5.5	6.2	7.1
E2		R	5.2	5.7	6.9	7.8	8.5
S1	Main North Road (South)	T	7.4	9.0	10.2	11.8	13.8
S2		T	4.4	6.0	8.1	11.0	16.2
S3		R	3.6	5.5	7.1	7.8	8.2
Changed Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Main North Road (North)	LT	2.9	3.7	4.7	5.6	6.7
N2		T	2.7	3.5	4.4	5.3	6.4
E1	Prestons Road	L	1.4	1.5	1.7	1.9	2.2
E2		R	1.7	1.9	2.4	2.6	3.0
S1	Main North Road (South)	T	2.3	2.9	3.6	4.1	5.0
S2		T	1.5	1.8	2.3	3.1	4.3
S3		R	1.4	1.9	2.4	2.9	3.5
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Main North Road (North)	LT	10.4	12.0	15.3	17.5	20.5
N2		T	8.1	10.6	12.0	14.8	17.9
E1	Prestons Road	L	3.4	4.2	5.3	6.1	7.1
E2		R	5.2	5.7	6.9	7.7	8.4
S1	Main North Road (South)	T	7.2	8.6	10.0	11.8	14.1
S2		T	4.6	6.1	8.1	11.7	16.2
S3		R	3.6	6.0	7.7	8.0	8.3

Method 2							
Existing Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Main North Road (North)	LT	3.7	3.6	3.5	3.2	3.1
N2		T	3.6	3.5	3.4	3.3	3.0
E1	Prestons Road	L	1.6	1.5	1.6	1.5	1.5
E2		R	2.1	1.9	1.9	1.8	1.8
S1	Main North Road (South)	T	3.1	2.9	2.7	2.6	2.6
S2		T	1.9	1.8	1.8	1.9	2.5
S3		R	1.3	1.8	2.3	2.8	3.9
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Main North Road (North)	LT	12.9	12.5	13.2	13.3	11.1
N2		T	10.3	10.9	10.2	10.1	9.2
E1	Prestons Road	L	4.5	4.2	4.1	4.1	3.7
E2		R	6.0	5.7	5.4	4.8	5.1
S1	Main North Road (South)	T	8.6	9.0	8.4	8.8	8.1
S2		T	6.1	6.0	7.3	6.8	12.1
S3		R	3.8	5.5	7.3	8.2	8.2
Changed Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Main North Road (North)	LT	3.9	3.7	3.7	3.3	3.2
N2		T	3.5	3.5	3.3	3.2	3.0
E1	Prestons Road	L	1.6	1.5	1.6	1.5	1.5
E2		R	2.1	1.9	2.0	1.8	1.8
S1	Main North Road (South)	T	3.0	2.9	2.7	2.7	2.7
S2		T	1.9	1.8	1.8	2.0	3.2
S3		R	1.4	1.9	2.5	3.1	4.4
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Main North Road (North)	LT	12.3	12.0	12.5	12.8	10.5
N2		T	10.2	10.6	10.0	9.8	9.3
E1	Prestons Road	L	4.5	4.2	4.1	4.1	3.7
E2		R	6.0	5.7	5.4	4.8	4.8
S1	Main North Road (South)	T	8.5	8.6	8.5	8.7	8.6
S2		T	6.1	6.1	7.3	8.0	13.7
S3		R	3.8	6.0	7.4	8.2	8.7

APPENDIX A8

Intersection 6 – Innes Road/Papanui Road Full Data

Table of Contents

A8.1 Approach Photos

Figure A8.1.1 - Papanui Road North Approach

Figure A8.1.3 - Papanui Road South Approach

Figure A8.1.2 - Innes Road East Approach

Figure A8.1.4 - Innes Road West Approach

A8.2 Surveyed Traffic Volume Data

Intersection 6: Innes Road/Papanui Road

Survey Date Wednesday, 8 November 2006

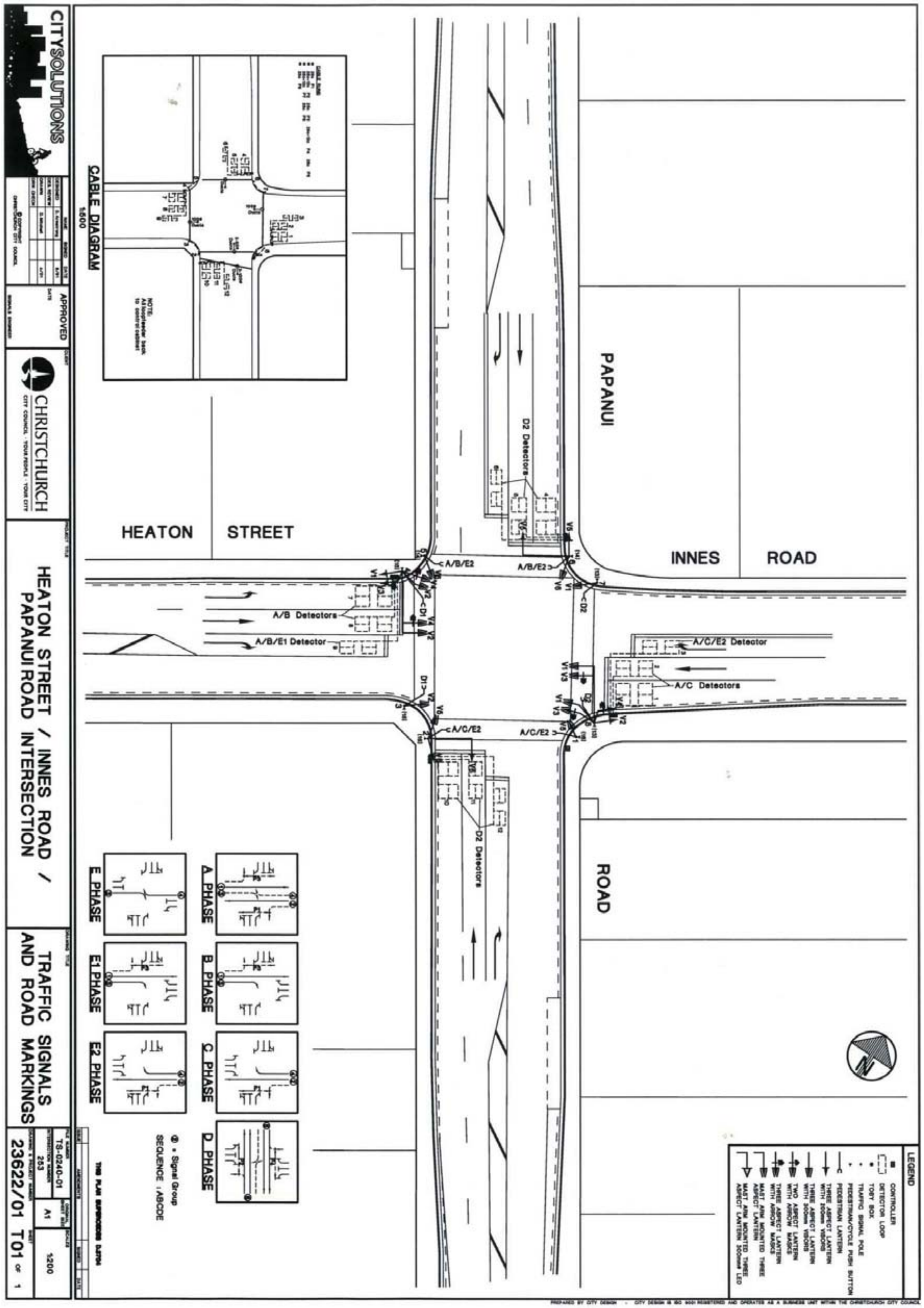
Light Vehicles			Papanui (South)			Innes (East)			Papanui (North)			Innes (West)			TOTAL
			L	T	R	L	T	R	L	T	R	L	T	R	
2:45	-	3:00	26	150	19	18	65	31	13	157	11	14	83	6	593
3:00	-	3:15	28	177	31	17	69	47	27	145	9	11	84	19	664
3:15	-	3:30	31	147	21	15	89	31	32	143	12	13	78	17	629
3:30	-	3:45	18	132	21	18	67	33	26	159	21	12	73	13	593
3:45	-	4:00	25	152	16	17	70	34	38	148	12	24	97	22	655
4:00	-	4:15	26	158	22	18	69	30	21	138	12	7	67	19	587

Heavy Vehicles			Papanui (South)			Innes (East)			Papanui (North)			Innes (West)			TOTAL
			L	T	R	L	T	R	L	T	R	L	T	R	
2:45	-	3:00	0	9	0	1	5	0	0	3	0	0	1	1	20
3:00	-	3:15	4	6	0	1	4	1	1	7	0	1	0	1	26
3:15	-	3:30	2	3	0	0	2	0	0	4	0	1	2	0	14
3:30	-	3:45	3	4	0	0	2	1	1	7	0	0	3	1	22
3:45	-	4:00	1	4	0	0	2	2	2	4	0	1	3	2	21
4:00	-	4:15	0	5	0	2	2	0	0	6	0	0	2	1	18

Total (2:45pm - 4:15pm)	Papanui (South)			Innes (East)			Papanui (North)			Innes (West)		
	L	T	R	L	T	R	L	T	R	L	T	R
Light	154	916	130	103	429	206	157	890	77	81	482	96
Heavy	10	31	0	4	17	4	4	31	0	3	11	6

Peak Hour (3:00pm - 4:00pm)	Papanui (South)			Innes (East)			Papanui (North)			Innes (West)		
	L	T	R	L	T	R	L	T	R	L	T	R
Light	102	608	89	67	295	145	123	595	54	60	332	71
Heavy	10	17	0	1	10	4	4	22	0	3	8	4

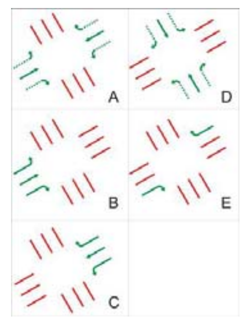
A8.3 Traffic Signal Plan



A8.4 Observed and Modelled Signal Timings

Table A4.5 - Intersection 6 Innes Road/Papanui Road (SCATS ID = 253)

Traffic Count Day		Wednesday 8 November, 2006		
Observed Signal Day		Thursday 21 September, 2006		
Observed Time Period		2:45pm to 4:15pm		
Observed Phase Timings				
Phase	Count	Minimum (s)	Maximum (s)	Average (s)
A	51	26	42	35
D	51	39	79	54
E	51	11	22	15
Cycle	-	-	-	104
Modelled Phase Timings				
A	-	-	-	29
D	-	-	-	66
E	-	-	-	10
Cycle	-	-	-	105



A8.5 Results Summary

A8.5.1 Journey Times Method 1

Figure A8.5.1 to Figure A8.5.4 present the average journey times for the four right turn movements at the intersection.

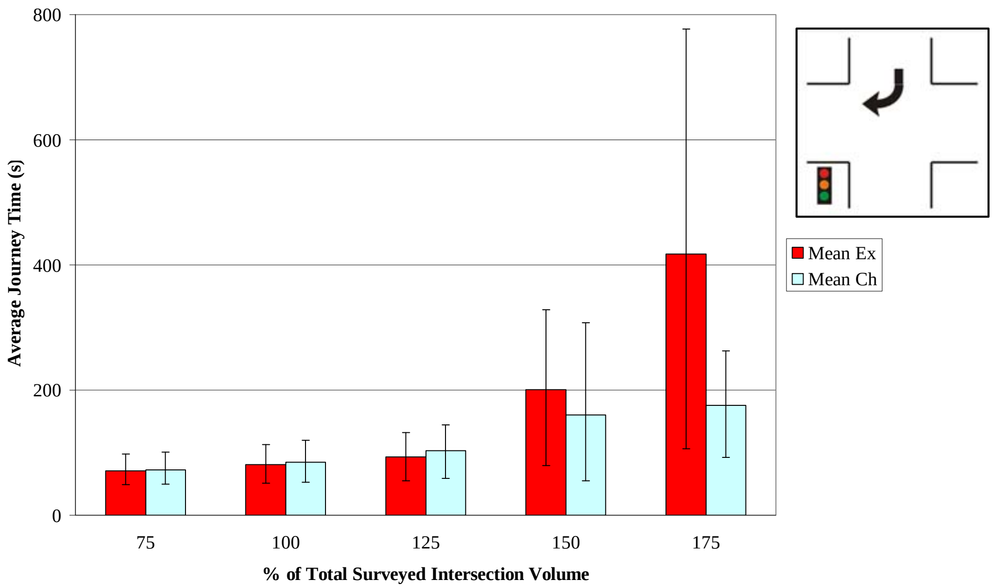


Figure A8.5.1 - Intersection 6, M1, Papanui Road (North) Right Turn Journey Time Comparison

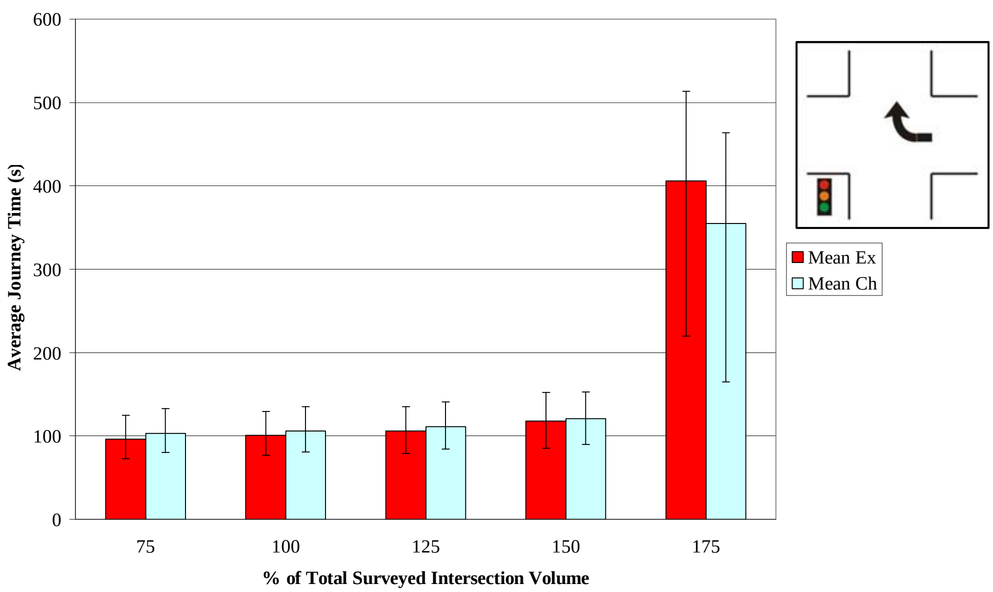


Figure A8.5.2 - Intersection 6, M1, Innes Road (East) Right Turn Journey Time Comparison

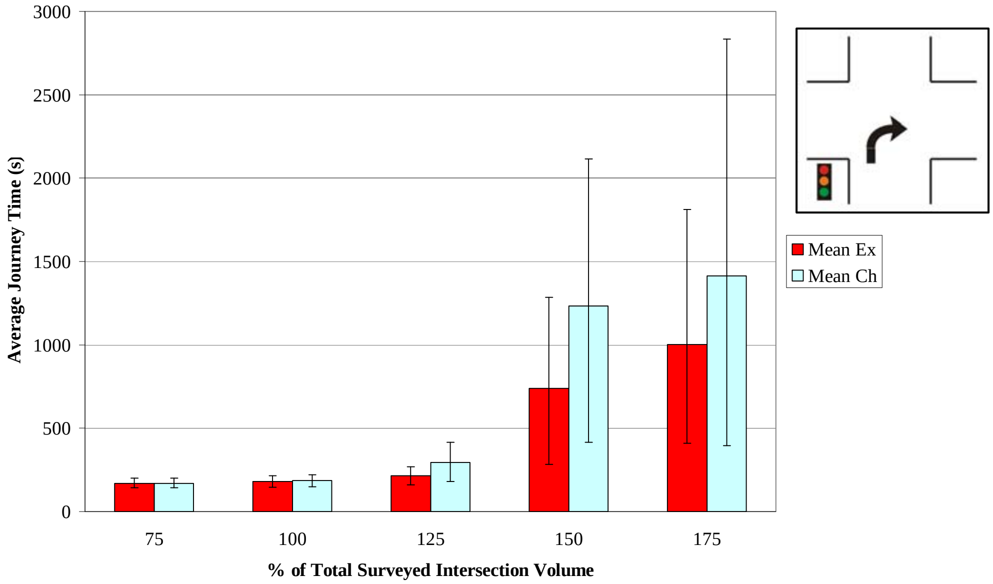


Figure A8.5.3 - Intersection 6, M1, Papanui Road (South) Right Turn Journey Time Comparison

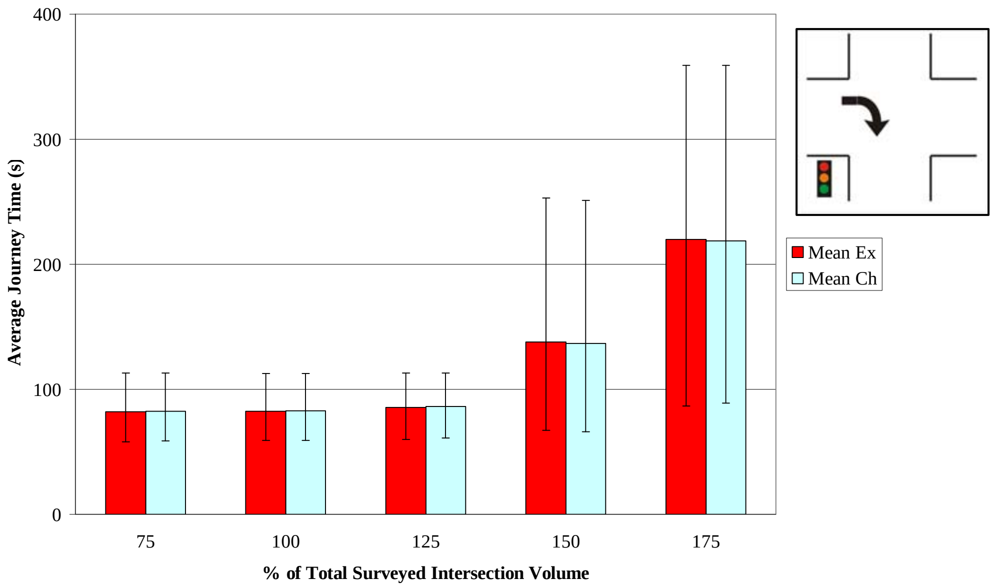


Figure A8.5.4 - Intersection 6, M1, Innes Road (West) Right Turn Journey Time Comparison

Figure A8.5.1 to Figure A8.5.4 shows that on the North and East approaches, under the higher volume scenarios, the changed rule results in shorted right turn journey times. This is counter intuitive and is due to the opposing approaches, from the South and West becoming blocked by overflowing right turn lanes. An example of this type of blocking, which also occurred at Intersection 2 (Breezes Road/Pages Road), was discussed in Section 5.2.1. The intersection is operating in a heavily congested manner as evidenced by the high journey times on the graphs.

Figure A8.5.5 to Figure A8.5.8 present the average journey times for the four left turn movements through the intersection.

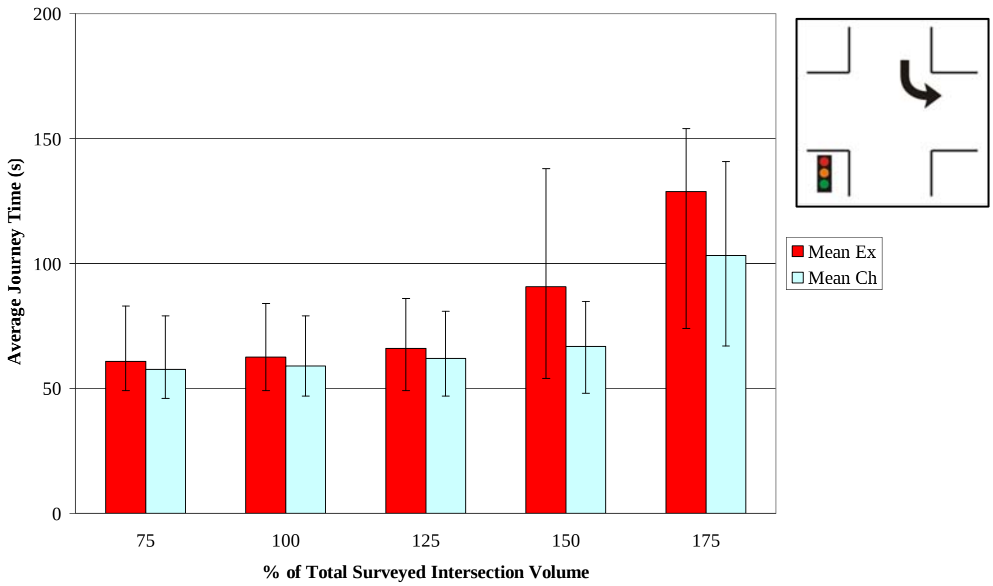


Figure A8.5.5 - Intersection 6, M1, Papanui Road (North) Left Turn Journey Time Comparison

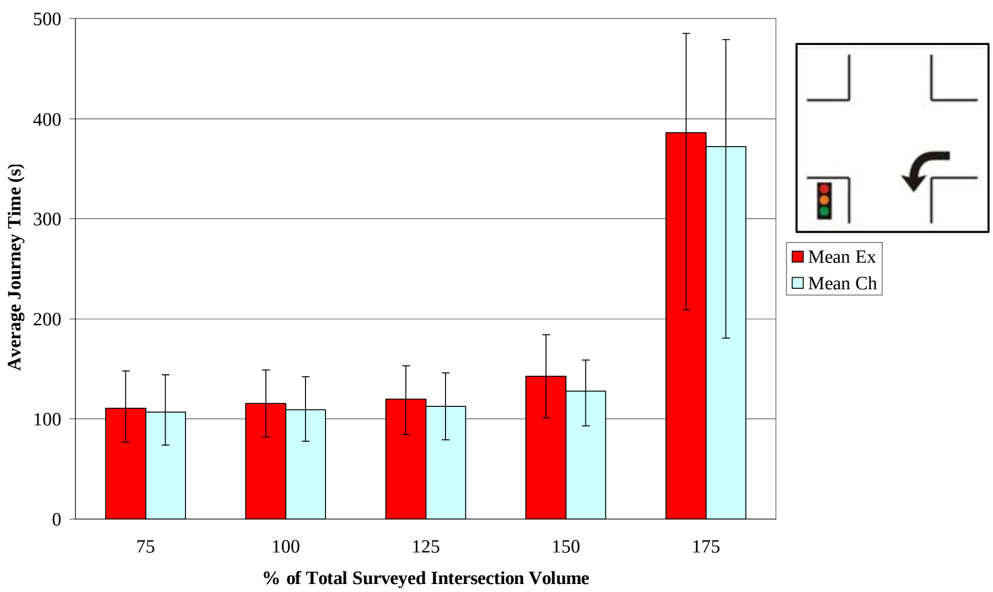


Figure A8.5.6 - Intersection 6, M1, Innes Road (East) Left Turn Journey Time Comparison

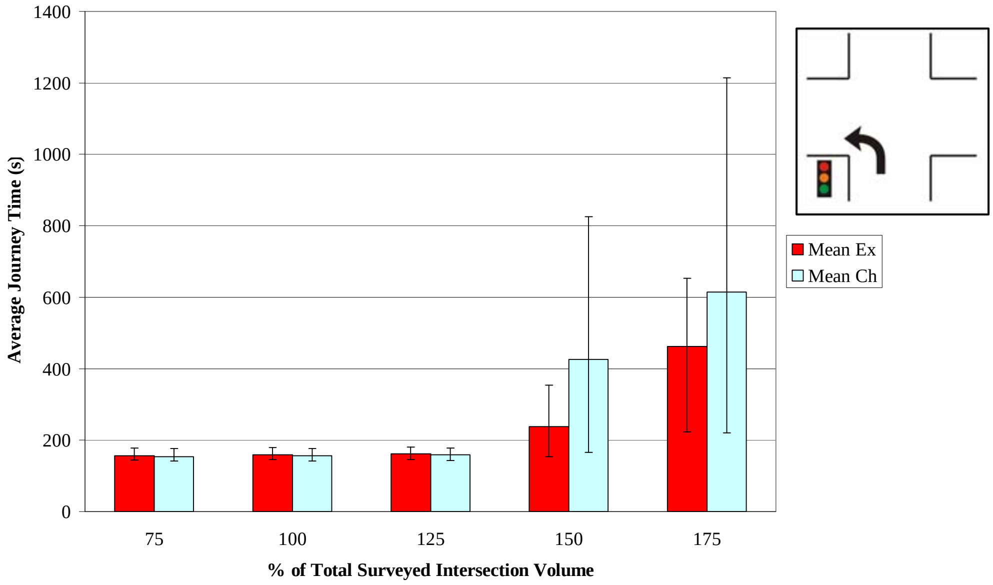


Figure A8.5.7 - Intersection 6, M1, Papanui Road (South) Left Turn Journey Time Comparison

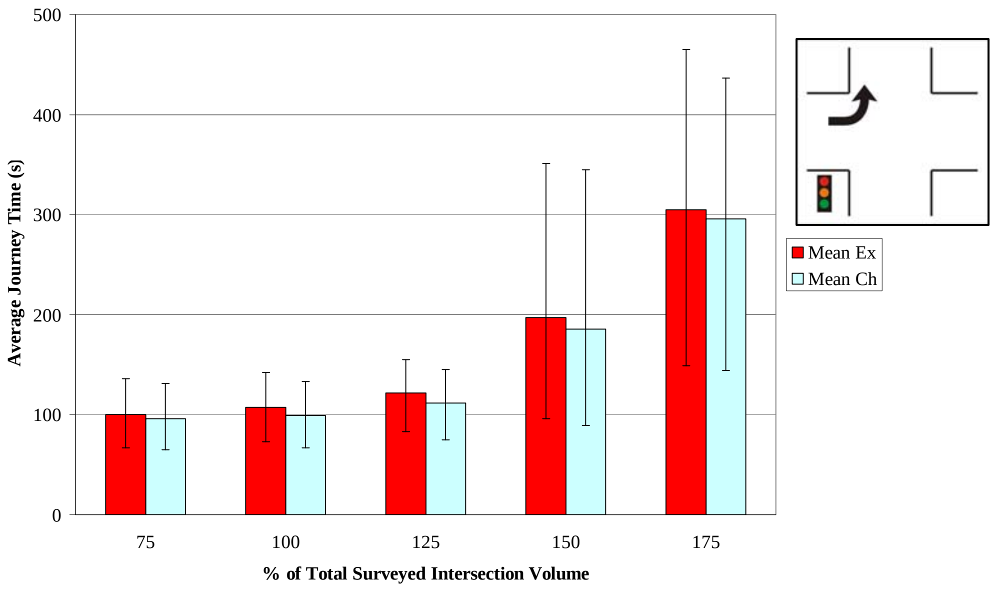


Figure A8.5.8 - Intersection 6, M1, Innes Road (West) Left Turn Journey Time Comparison

Figure A8.5.5 to Figure A8.5.8 show a mixture of some increases and some decreases in left turn journey time. When the intersection is operating without blocked approaches there is a general pattern of a reduction in left turn journey times. However when the right turn lanes become full some approaches become blocked and all movements on the approach are affected. Figure A8.5.9 shows the average journey time for all movements through the intersection.

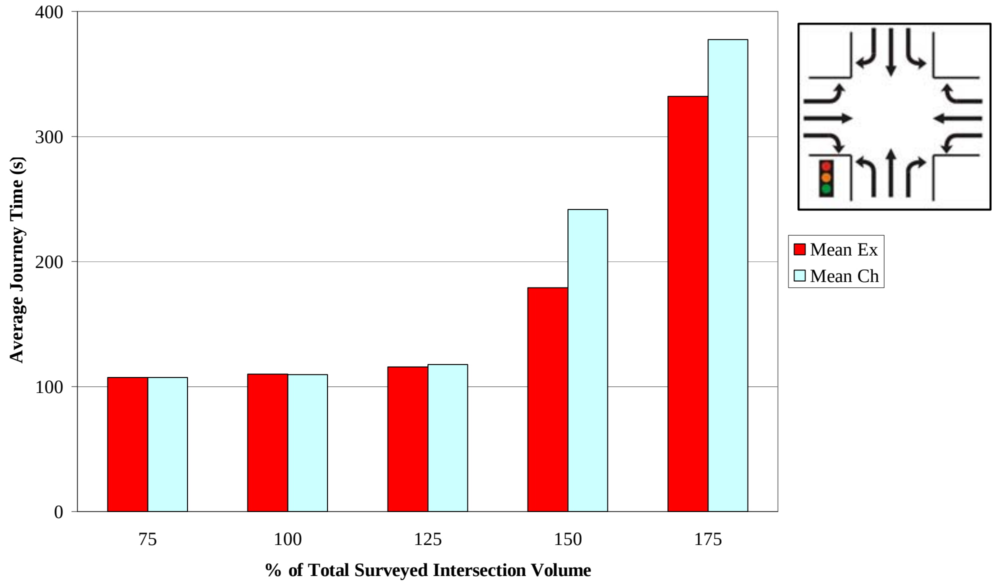


Figure A8.5.9 - Intersection 6, M1, Total Intersection Journey Time Comparison

A8.5.2 Journey Times Method 2

Figure A8.5.10 to Figure A8.5.13 present the average journey times for the four right turn movements at the intersection.

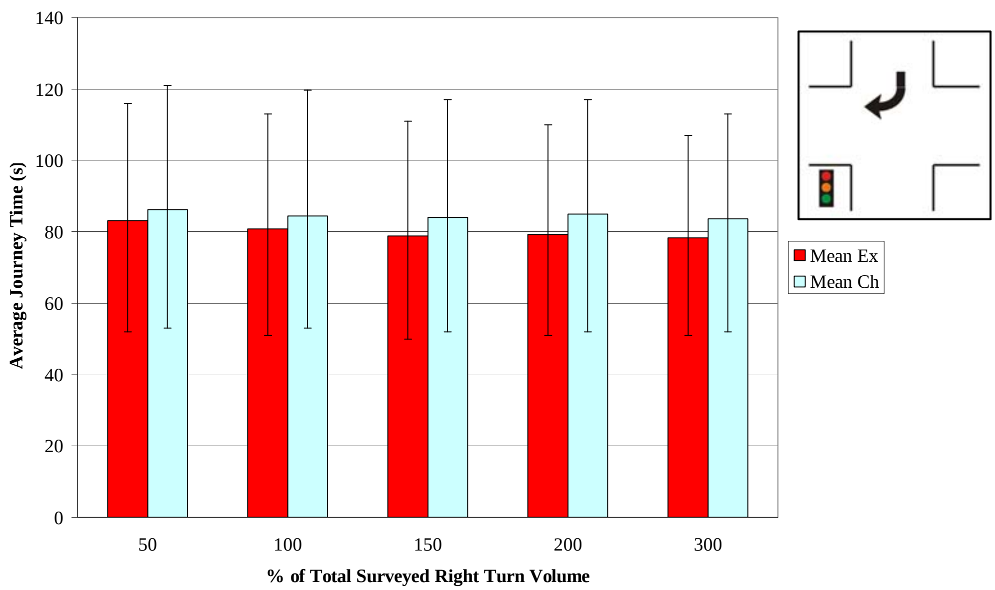


Figure A8.5.10 - Intersection 6, M2, Papanui Road (North) Right Turn Journey Time Comparison

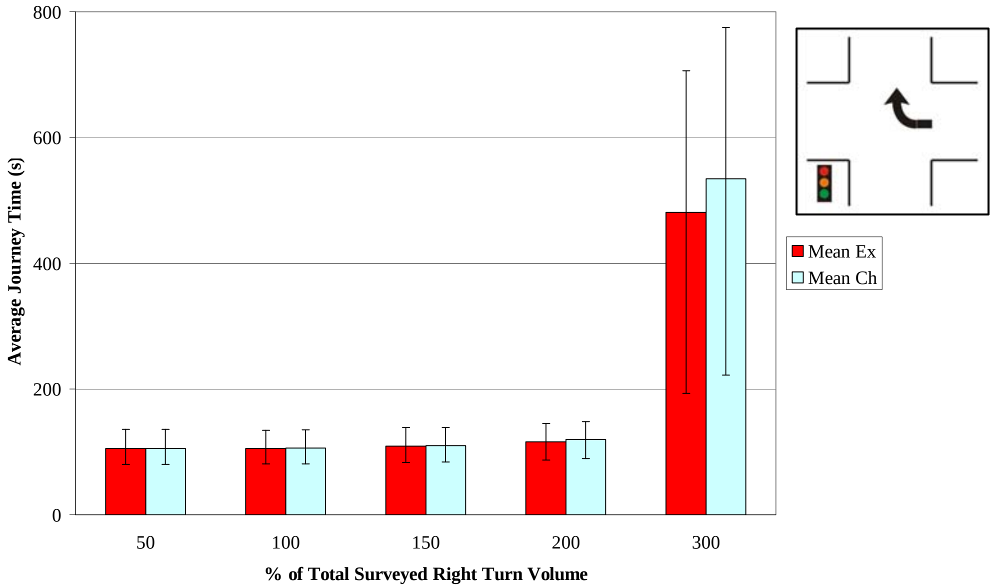


Figure A8.5.11 - Intersection 6, M2, Innes Road (East) Right Turn Journey Time Comparison

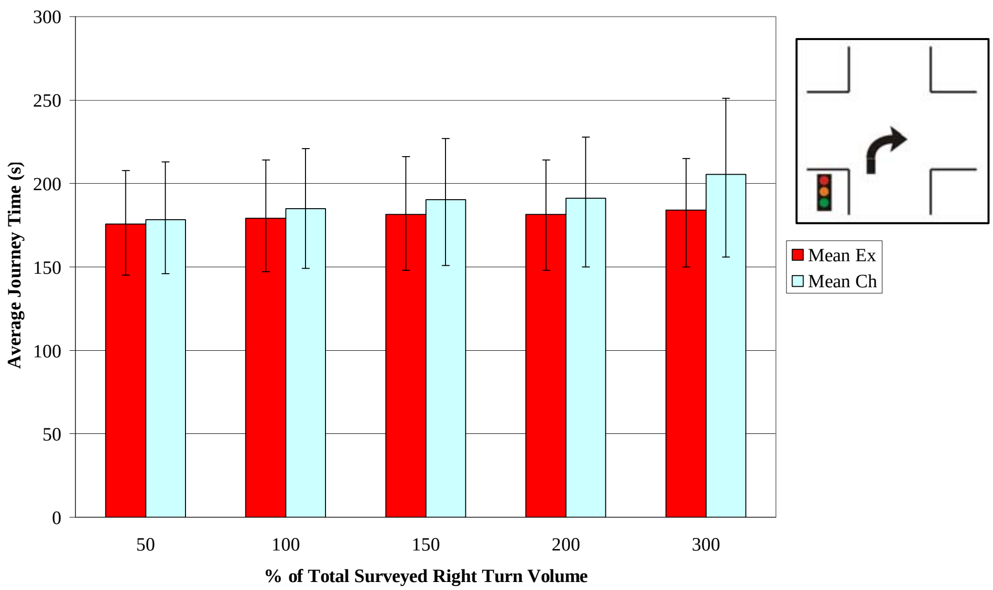


Figure A8.5.12 - Intersection 6, M2, Papanui Road (South) Right Turn Journey Time Comparison

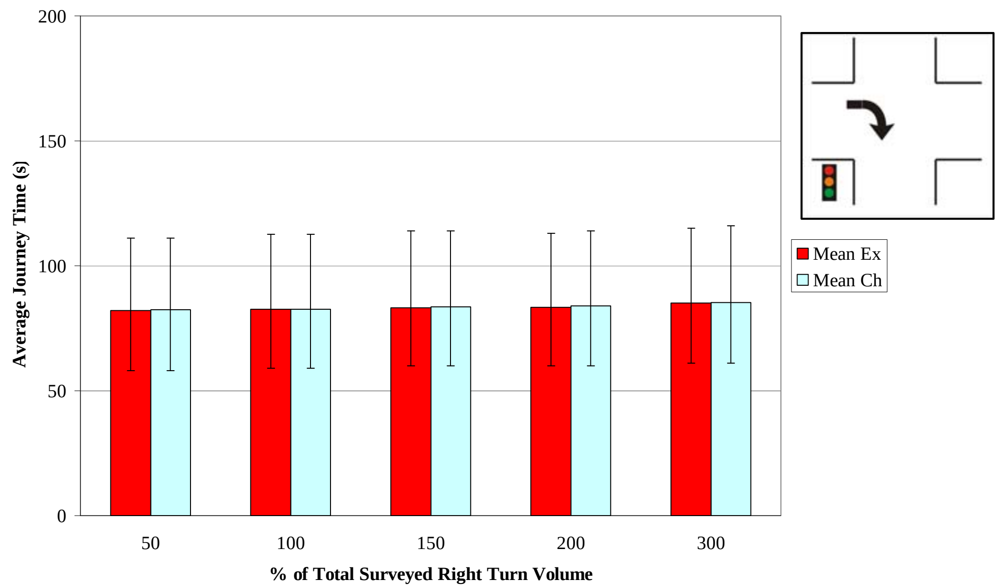


Figure A8.5.13 - Intersection 6, M2, Innes Road (West) Right Turn Journey Time Comparison

Figure A8.5.14 to Figure A8.5.17 present the average journey times for the four left turn movements at the intersection.

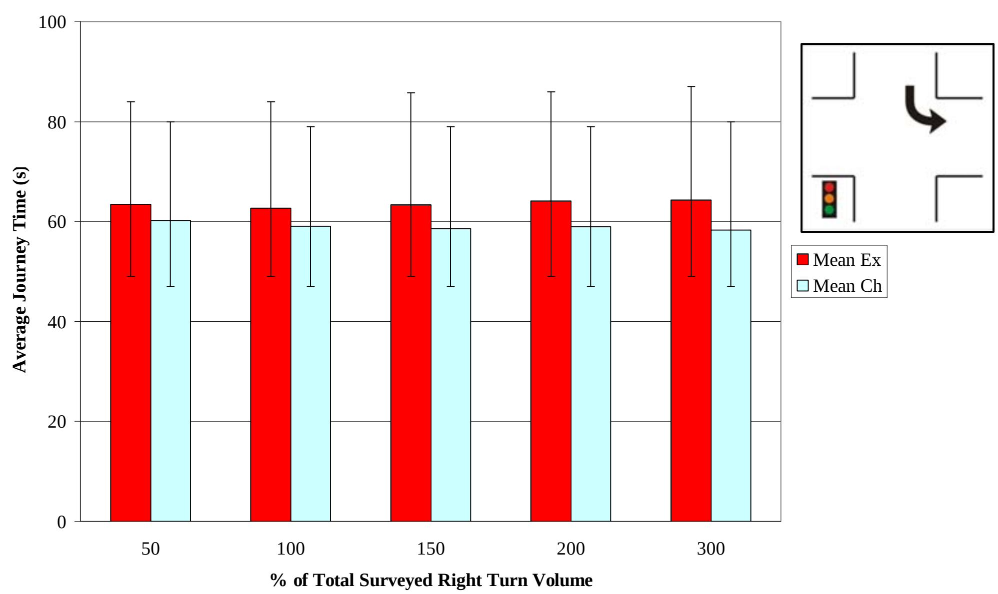


Figure A8.5.14 - Intersection 6, M2, Papanui Road (North) Left Turn Journey Time Comparison

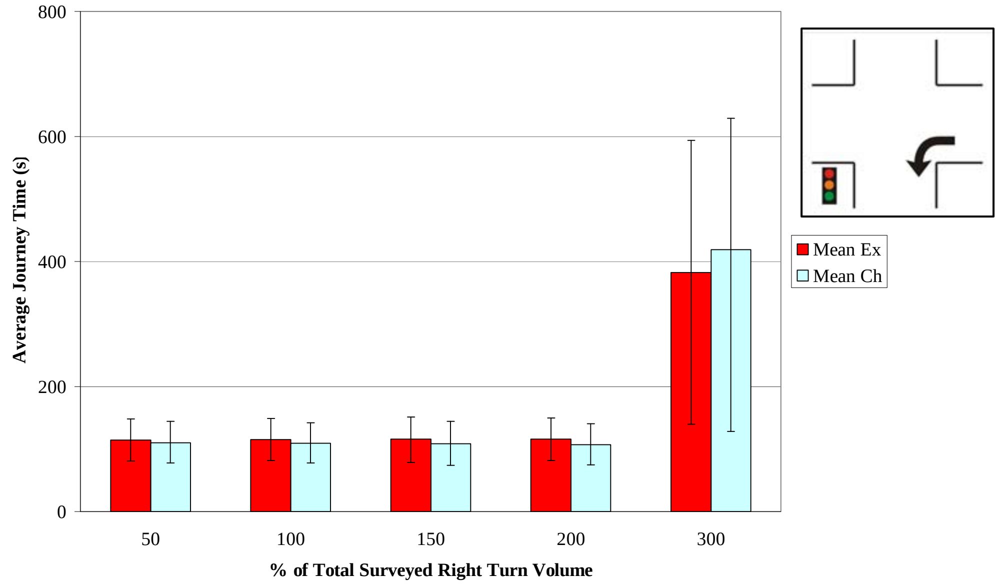


Figure A8.5.15 - Intersection 6, M2, Innes Road (East) Left Turn Journey Time Comparison

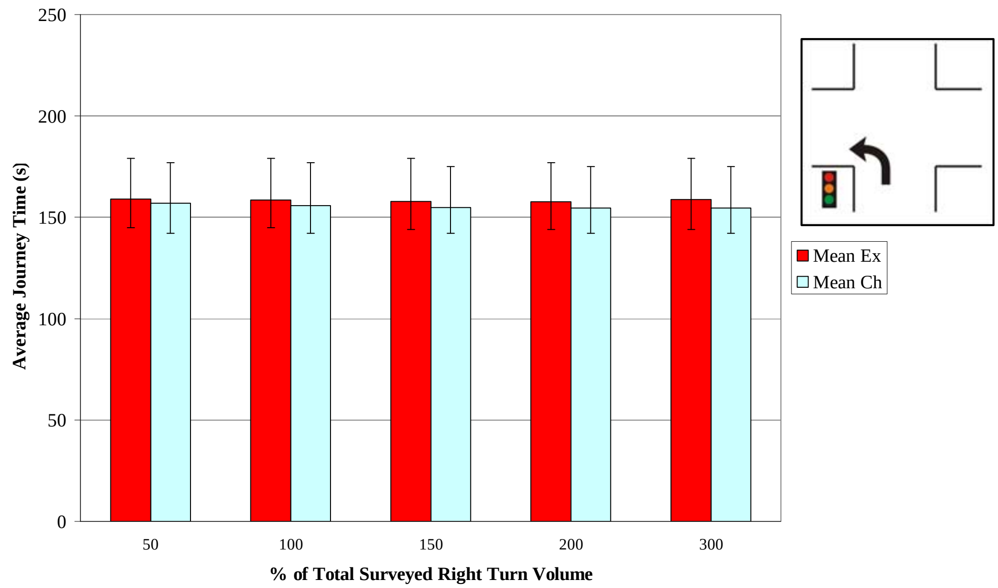


Figure A8.5.16 - Intersection 6, M2, Papanui Road (South) Left Turn Journey Time Comparison

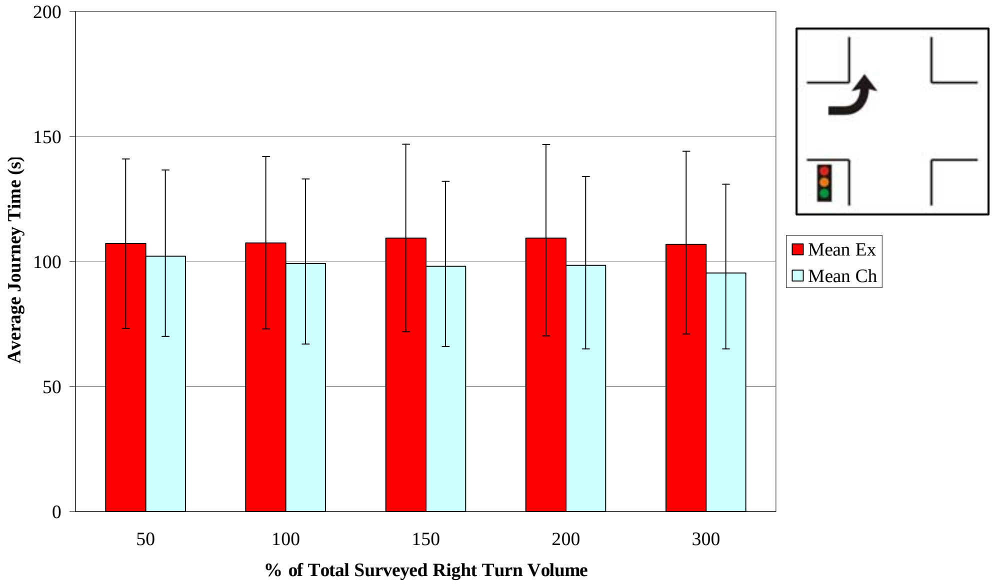


Figure A8.5.17 - Intersection 6, M2, Innes Road (West) Left Turn Journey Time Comparison

Figure A8.5.18 presents the average journey time for all movements through the intersection under each rule.

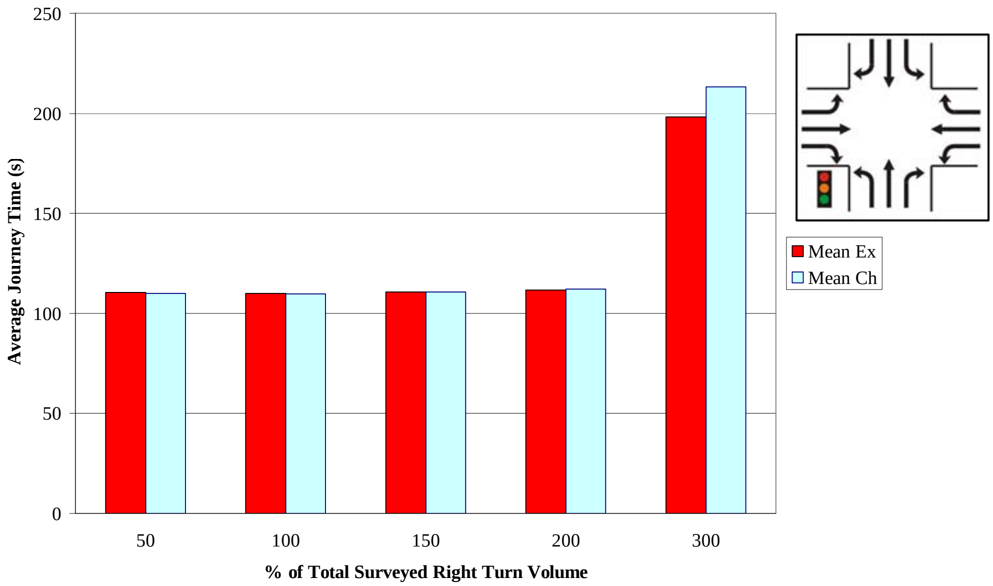


Figure A8.5.18 - Intersection 6, M2, Total Intersection Journey Time Comparison

Table A8.5.1 summarises the average journey time for all movements for each volume scenario.

Table A8.5.1 - Intersection 6, M2, Average Journey Time Comparison

Approach	Mvt	Average Journey Time (seconds/vehicle) for Various % Scenarios									
		50%		100%		150%		200%		300%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Papanui Road (North)	L	63	60	63	59	63	59	64	59	64	58
	T	63	63	62	62	62	62	62	62	60	61
	R	83	86	81	84	79	84	79	85	78	84
Innes Road (East)	L	115	110	115	109	116	109	116	107	383	419
	T	108	108	107	107	106	106	105	105	367	415
	R	105	105	105	106	109	110	116	120	481	534
Papanui Road (South)	L	159	157	159	156	158	155	158	155	159	155
	T	166	166	165	165	165	165	164	164	163	163
	R	176	178	179	185	181	190	181	191	184	206
Innes Road (West)	L	107	102	107	99	109	98	109	98	107	95
	T	94	94	91	91	91	91	89	89	90	90
	R	82	82	83	83	83	84	83	84	85	85
Total	All	110	110	110	110	111	111	112	112	198	213

Table A8.5.2 presents a comparison for the increase or decrease in journey time for each right turn and the opposing left turn.

Table A8.5.2 - Intersection 6, M2, Right and Left Turn Journey Time Changes

Movement	Change in Average Journey Time (seconds/vehicle) for Various % Scenarios				
	75%	100%	125%	150%	175%
Papanui Road (North) R	3.1	3.6	5.2	5.7	5.4
Papanui Road (South) L	-2.2	-2.7	-3.1	-3.1	-4.2
Innes Road (East) R	0.3	0.6	0.9	3.6	53.8
Innes Road (West) L	-5.0	-8.2	-11.4	-10.8	-11.4
Papanui Road (South) R	2.6	5.9	8.9	9.7	21.4
Papanui Road (North) L	-3.2	-3.6	-4.8	-5.2	-6.0
Innes Road (West) R	0.3	0.1	0.4	0.6	0.3
Innes Road (East) L	-4.6	-6.0	-7.6	-8.9	36.3

On the North, East and South approaches there is a consistent pattern of a small increase in journey time for right turns and a small decrease in journey times for left turns. The West approach is more sensitive and as the proportion of right turning vehicles increases in the latter scenarios this movement experiences sharp increases in journey time. The increase is greater under the changed rule.

A8.5.3 Queue Lengths Method 1

Figure A8.5.19 to Figure A8.5.22 present queue length comparisons for all lanes accommodating right turns at the intersection. All approaches have separate right turn lanes.

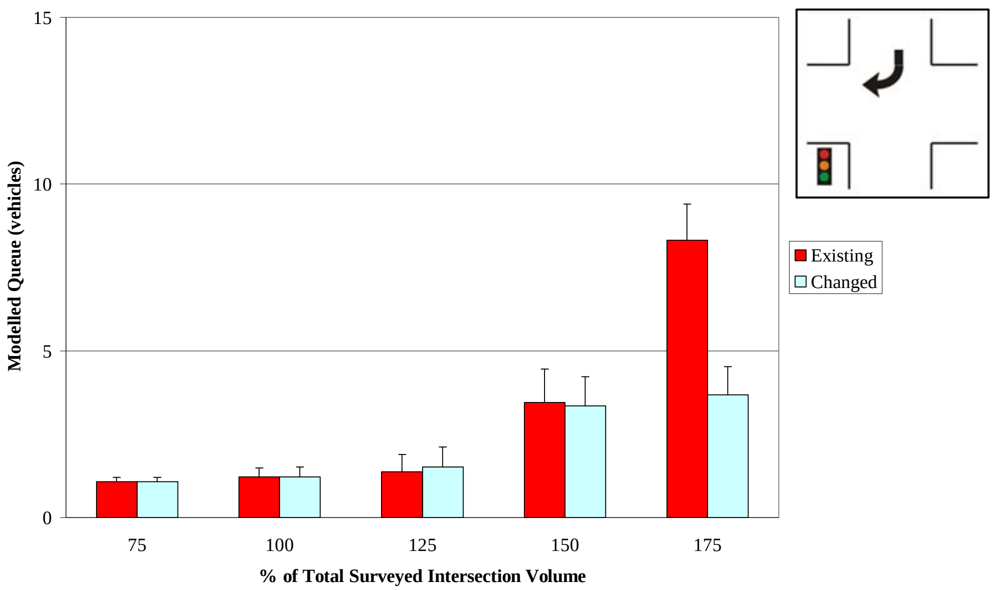


Figure A8.5.19 - Intersection 6, M1, Papanui Road (North) Right Turn Queue Comparison

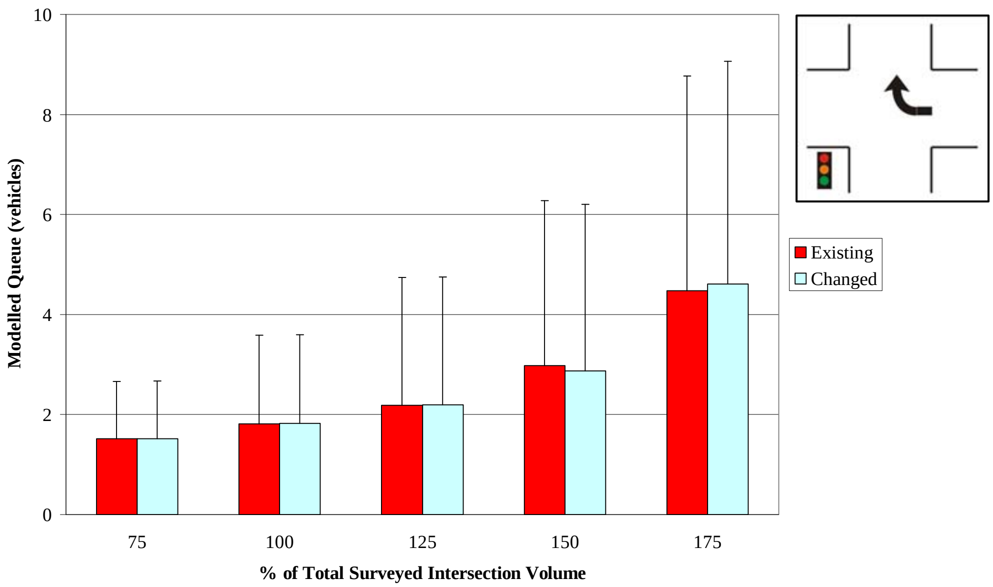


Figure A8.5.20 - Intersection 6, M1, Innes Road (East) Right Turn Queue Comparison

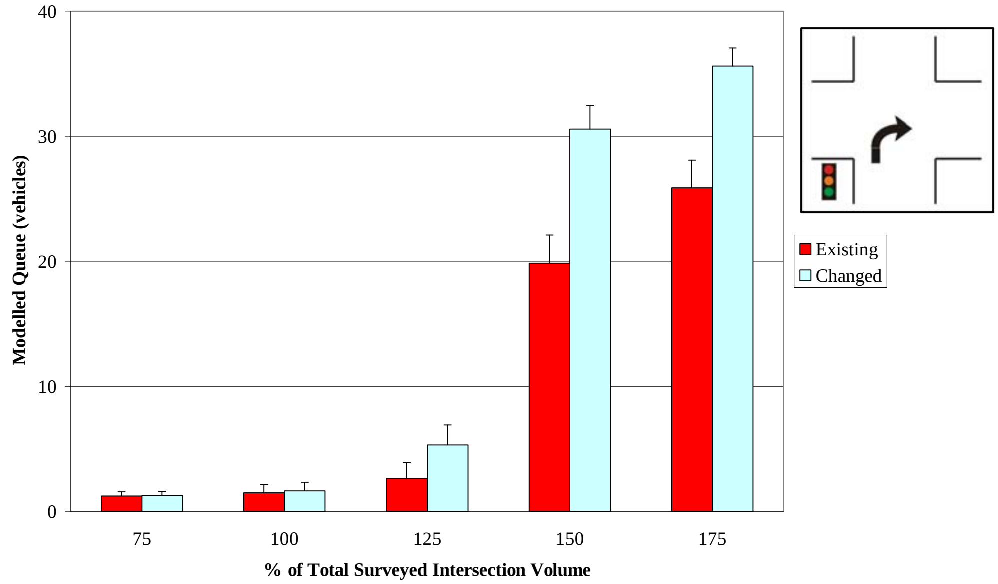


Figure A8.5.21 - Intersection 6, M1, Papanui Road (South) Right Turn Queue Comparison

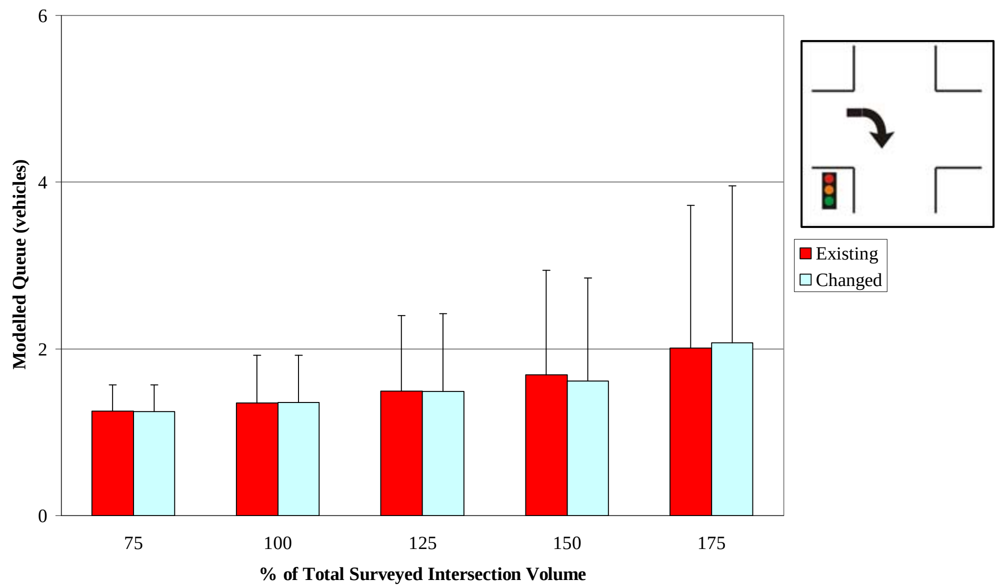


Figure A8.5.22 - Intersection 6, M1, Innes Road (West) Right Turn Queue Comparison

Figure A8.5.23 to Figure A8.5.26 present queue length comparisons for all lanes accommodating left turns at the intersection. All approaches have separate left turn lanes.

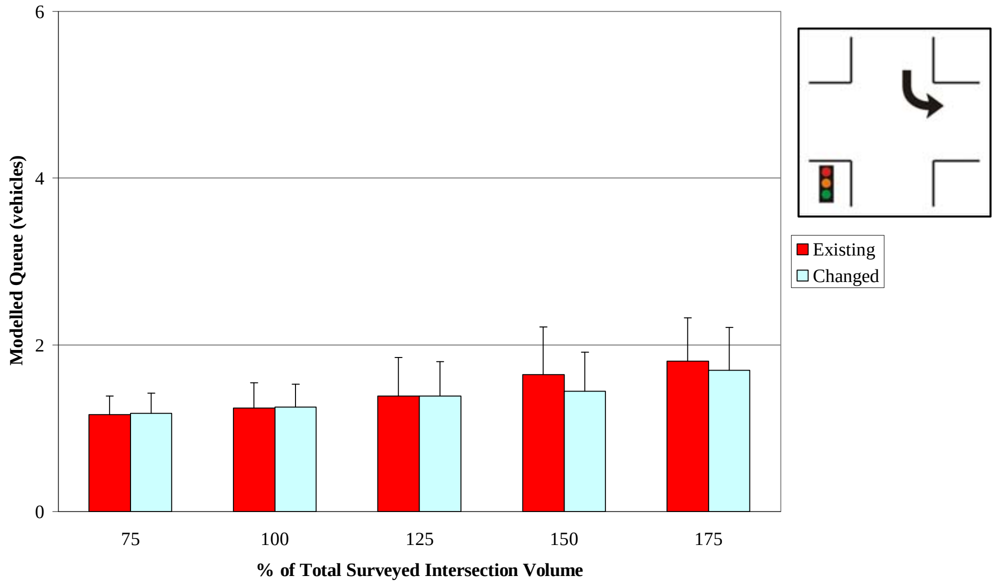


Figure A8.5.23 - Intersection 6, M1, Papanui Road (North) Left Turn Queue Comparison

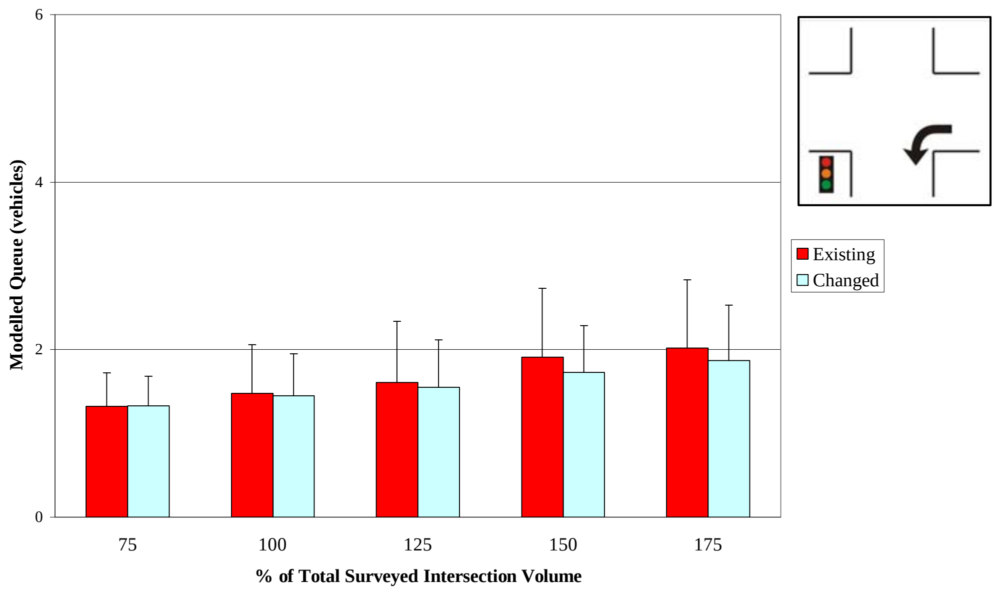


Figure A8.5.24 - Intersection 6, M1, Innes Road (East) Left Turn Queue Comparison

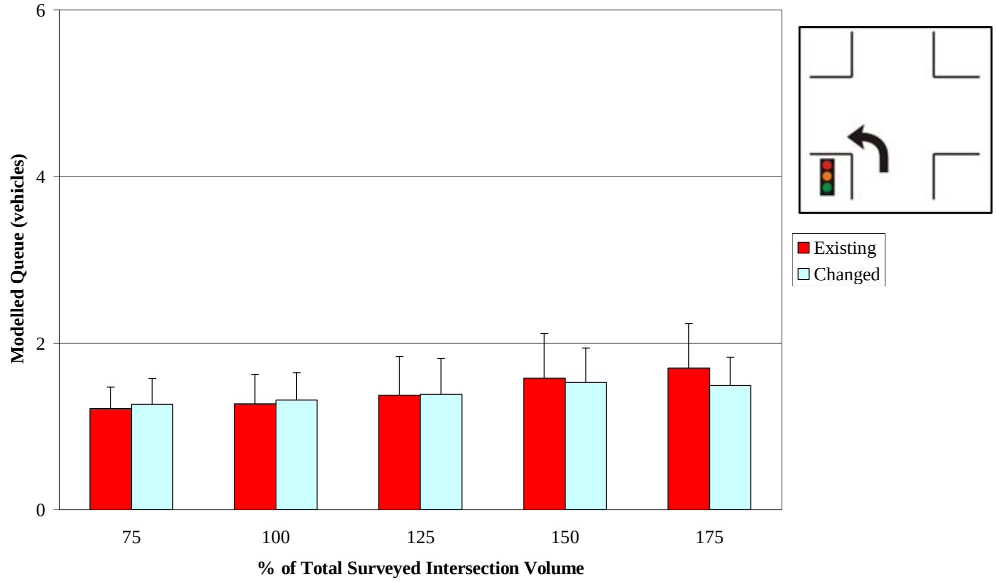


Figure A8.5.25 - Intersection 6, M1, Papanui Road (South) Left Turn Queue Comparison

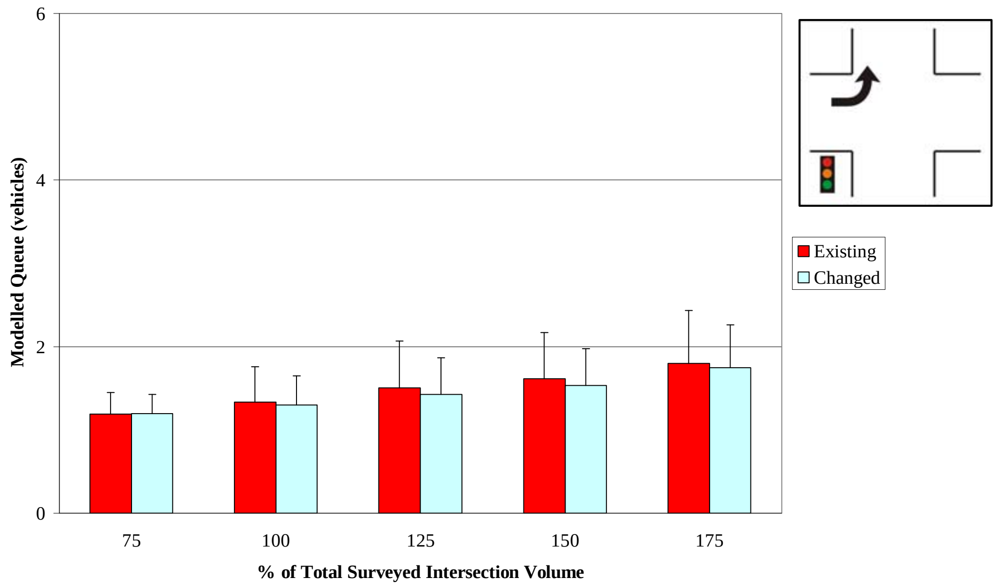


Figure A8.5.26 - Intersection 6, M1, Innes Road (West) Left Turn Queue Comparison

A8.5.4 Queue Lengths Method 2

Figure A8.5.27 to Figure A8.5.30 present queue length comparisons for all lanes accommodating right turns at the intersection. All approaches have separate right turn lanes.

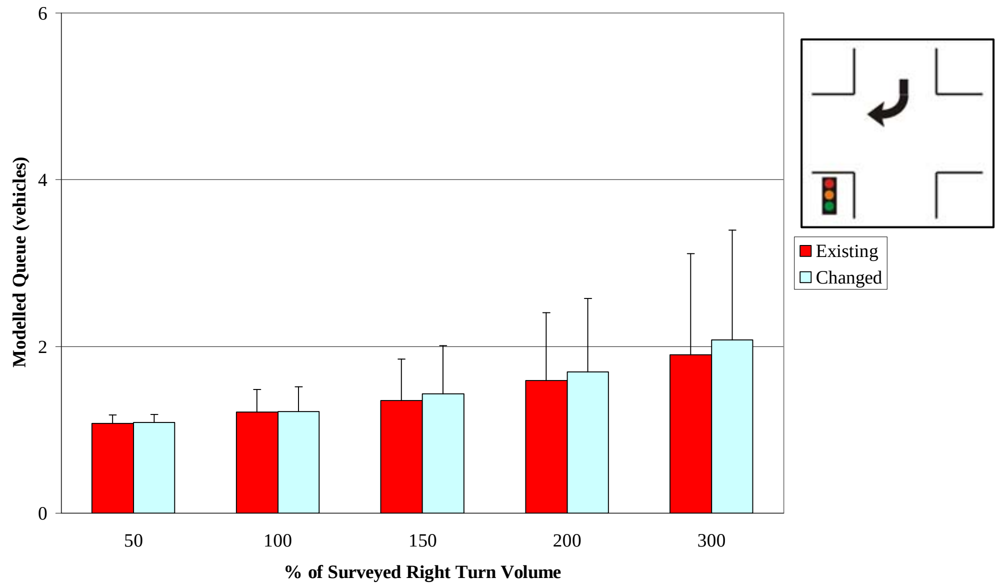


Figure A8.5.27 - Intersection 6, M2, Papanui Road (North) Right Turn Queue Comparison

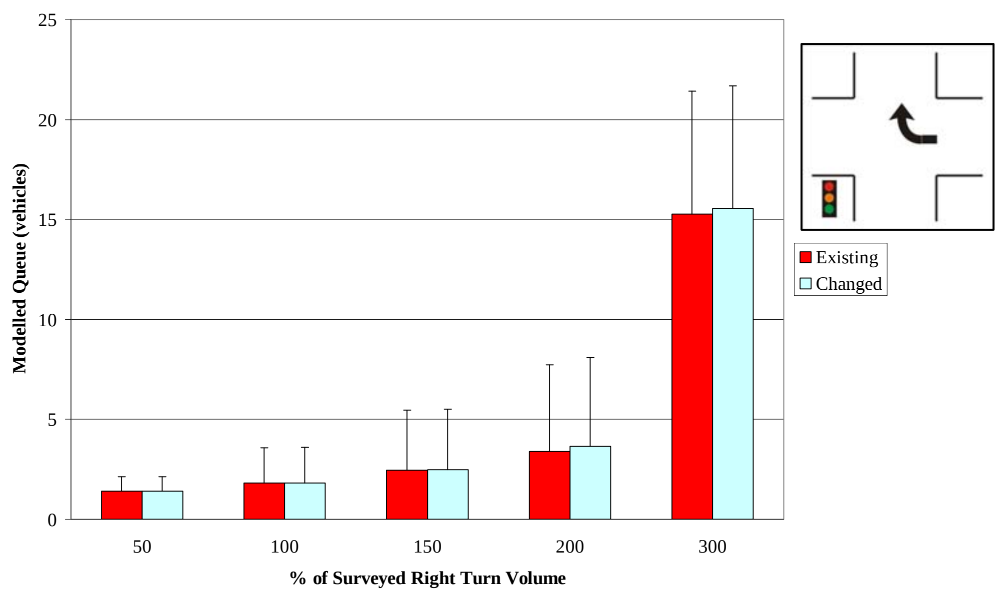


Figure A8.5.28 - Intersection 6, M2, Innes Road (East) Right Turn Queue Comparison

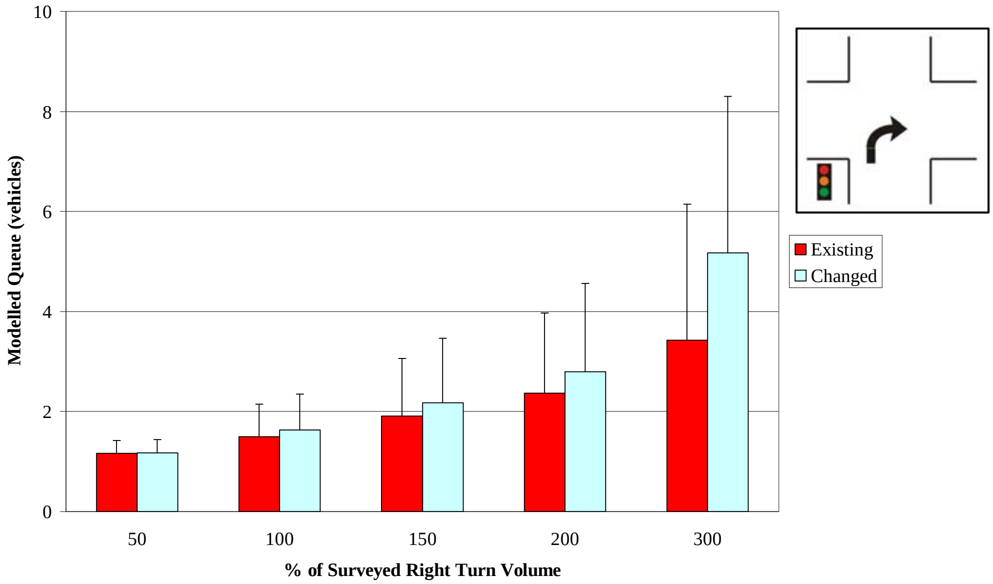


Figure A8.5.29 - Intersection 6, M2, Papanui Road (South) Right Turn Queue Comparison

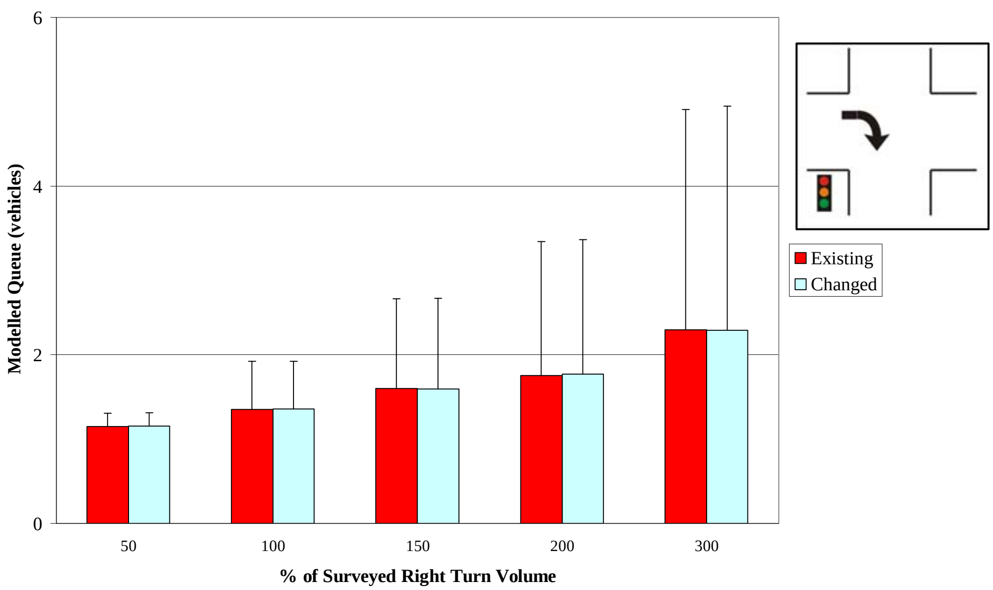


Figure A8.5.30 - Intersection 6, M2, Innes Road (West) Right Turn Queue Comparison

Figure A8.5.31 to Figure A8.5.34 present queue length comparisons for all lanes accommodating left turns at the intersection. All approaches have separate left turn lanes.

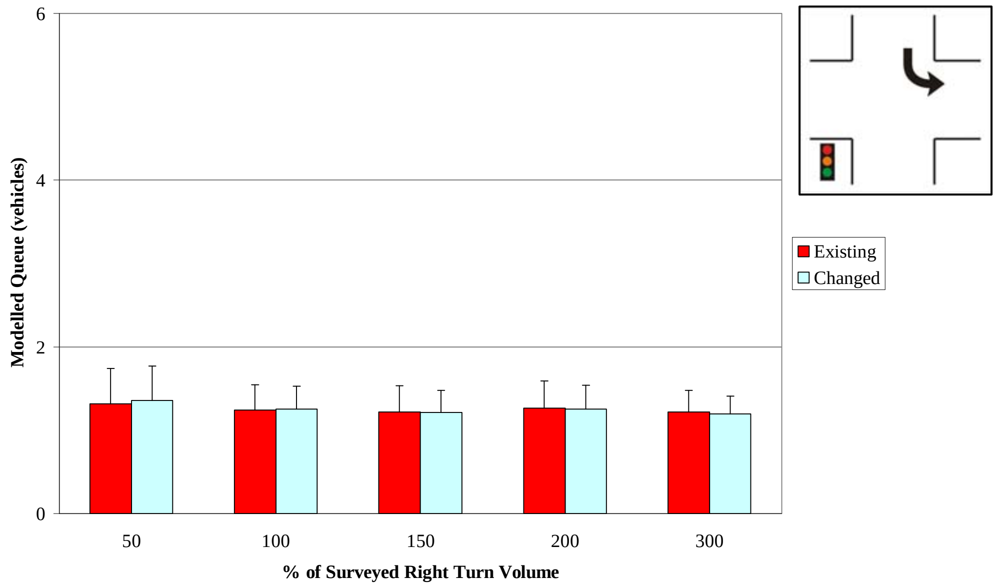


Figure A8.5.31 - Intersection 6, M2, Papanui Road (North) Left Turn Queue Comparison

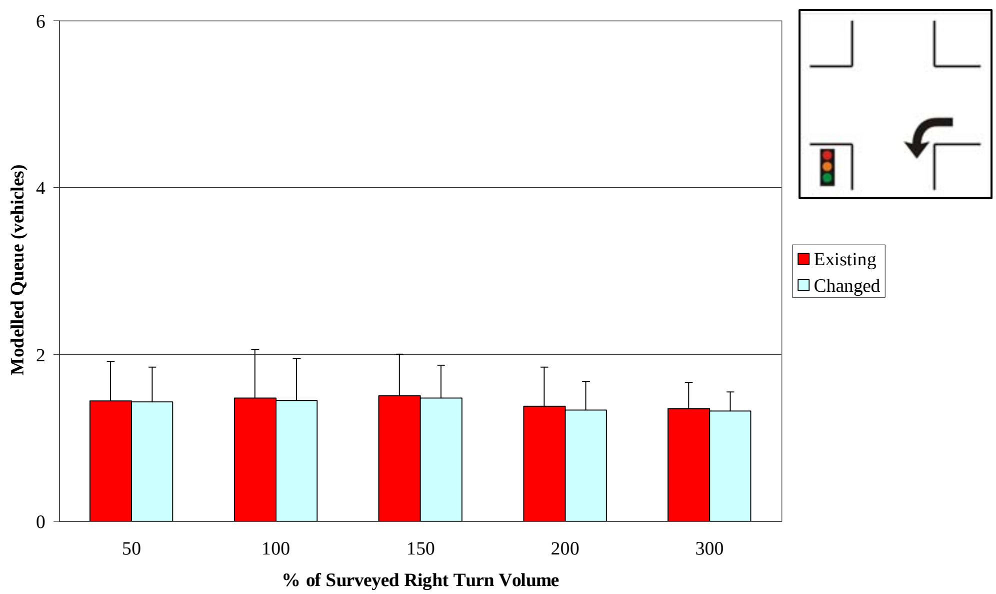


Figure A8.5.32 - Intersection 6, M2, Innes Road (East) Left Turn Queue Comparison

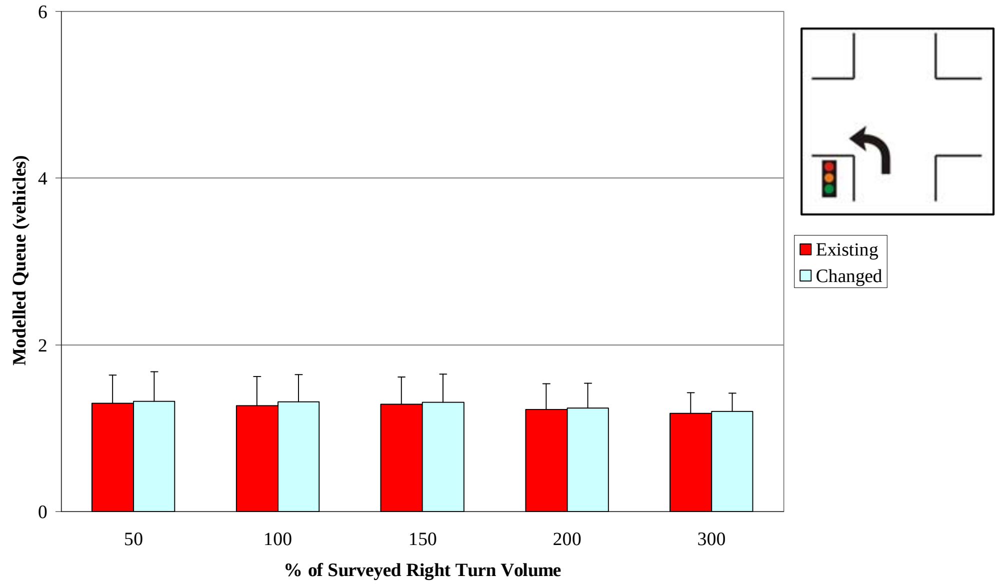


Figure A8.5.33 - Intersection 6, M2, Papanui Road (South) Left Turn Queue Comparison

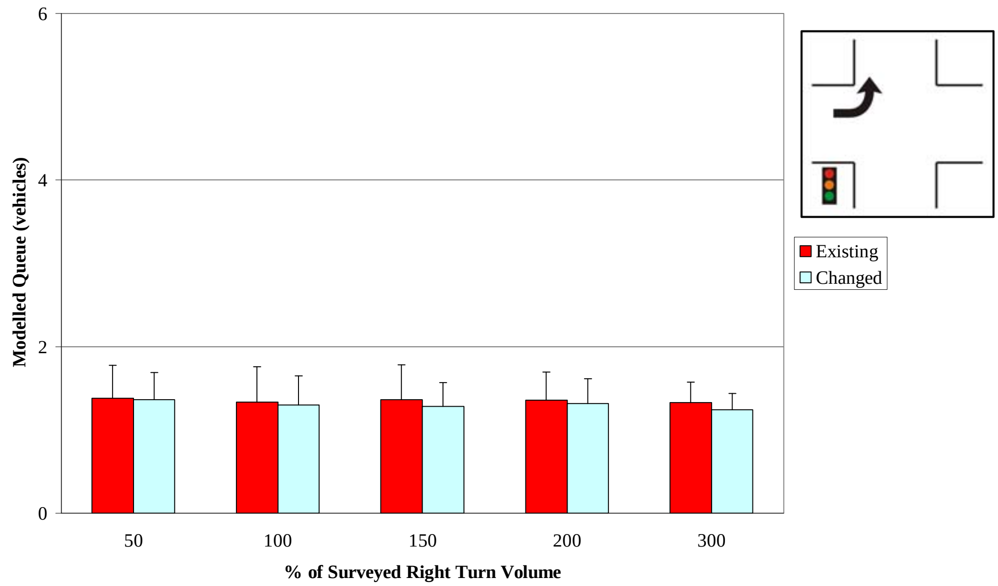


Figure A8.5.34 - Intersection 6, M2, Innes Road (West) Left Turn Queue Comparison

Table A8.5.3 summarises the average queue lengths for each volume scenario.

Table A8.5.3 - Intersection 6, M2, Average Queue Comparison

Approach	Mvt	Average Queue Length (vehicles) for Various % Scenarios									
		50%		100%		150%		200%		300%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Papanui Road (North)	L	1.3	1.4	1.2	1.3	1.2	1.2	1.3	1.3	1.2	1.2
	T	4.8	4.8	4.5	4.5	4.1	4.1	3.8	3.8	3.1	3.1
	R	1.1	1.1	1.2	1.2	1.4	1.4	1.6	1.7	1.9	2.1
Innes Road (East)	L	1.4	1.4	1.5	1.4	1.5	1.5	1.4	1.3	1.3	1.3
	T	4.6	4.6	4.2	4.2	3.9	3.9	3.5	3.5	17.1	18.0
	R	1.4	1.4	1.8	1.8	2.5	2.5	3.4	3.6	15.3	15.6
Papanui Road (South)	L	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2
	T	4.9	4.9	4.5	4.5	4.2	4.2	3.7	3.7	3.0	3.0
	R	1.2	1.2	1.5	1.6	1.9	2.2	2.4	2.8	3.4	5.2
Innes Road (West)	L	1.4	1.4	1.3	1.3	1.4	1.3	1.4	1.3	1.3	1.2
	T	4.8	4.8	4.3	4.3	4.1	4.1	3.7	3.7	3.1	3.1
	R	1.1	1.2	1.4	1.4	1.6	1.6	1.8	1.8	2.3	2.3

The volume scenarios tested under Method 2 have not shown any major differences in right or left turn queue length. All right turn queue lengths increase slightly as the result of a rule change to nearside priority with the largest increase being from 3.4 to 5.2 vehicles on the Papanui Road (South) approach. The left turn queue lengths are unaffected.

A8.6 Full Journey Time Analysis Results

Method 1 Existing Rule							
Mean Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Papanui Road (North)	L	60.9	62.7	66.0	90.7	128.8
NT		T	60.5	62.2	65.1	88.5	126.4
NR		R	70.8	80.9	93.1	200.6	417.6
EL	Innes Road (East)	L	110.5	115.3	119.8	142.5	386.2
ET		T	104.6	106.7	108.7	129.1	373.7
ER		R	103.0	105.5	110.8	122.7	356.3
SL	Papanui Road (South)	L	156.5	158.5	161.4	237.1	461.6
ST		T	163.5	165.5	168.3	242.3	466.7
SR		R	167.5	179.1	215.5	738.1	1003.2
WL	Innes Road (West)	L	100.2	107.5	121.5	196.9	304.9
WT		T	88.7	91.0	101.4	176.9	287.1
WR		R	82.1	82.6	85.3	137.8	219.7
All Movements		All	107.4	110.0	115.5	178.9	332.2
Median Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Papanui Road (North)	L	54.0	57.0	62.0	76.0	132.0
NT		T	52.0	56.0	62.0	77.0	128.0
NR		R	62.0	77.0	88.0	177.0	313.0
EL	Innes Road (East)	L	106.0	113.0	119.0	140.0	450.0
ET		T	103.0	106.0	108.0	128.0	437.0
ER		R	96.0	101.0	106.0	118.0	406.0
SL	Papanui Road (South)	L	150.0	152.0	156.0	179.0	421.0
ST		T	156.0	160.0	165.0	187.0	425.0
SR		R	160.0	173.0	206.0	606.0	800.0
WL	Innes Road (West)	L	95.0	104.0	120.0	153.0	293.0
WT		T	87.0	89.0	101.0	132.0	276.0
WR		R	73.0	76.0	81.0	107.0	203.0
All Movements		All	98.0	102.0	108.0	145.0	283.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Papanui Road (North)	L	49.0	49.0	49.0	54.0	74.0
NT		T	46.0	47.0	47.0	48.0	71.0
NR		R	49.0	51.0	55.0	79.4	106.0
EL	Innes Road (East)	L	76.9	82.0	84.5	101.0	209.0
ET		T	69.0	70.0	75.0	89.0	191.2
ER		R	80.0	81.0	84.0	90.0	170.3
SL	Papanui Road (South)	L	144.0	145.0	146.0	154.0	223.5
ST		T	148.0	148.0	150.0	157.0	230.0
SR		R	144.0	147.0	160.0	283.8	410.0
WL	Innes Road (West)	L	67.0	73.0	83.0	96.0	149.0
WT		T	53.0	55.0	64.0	79.0	132.0
WR		R	58.0	59.0	60.0	67.0	86.7
All Movements		All	52.0	53.0	59.0	72.0	108.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Papanui Road (North)	L	83.0	84.0	86.0	138.0	154.0
NT		T	83.0	85.0	87.0	137.0	153.0
NR		R	98.0	113.0	132.0	328.0	777.0
EL	Innes Road (East)	L	148.0	149.0	153.0	184.0	485.0
ET		T	141.0	142.0	143.0	167.0	477.0
ER		R	132.0	134.0	140.0	157.0	464.0
SL	Papanui Road (South)	L	178.0	179.0	181.0	354.6	653.5
ST		T	187.0	188.0	191.0	358.0	660.0
SR		R	199.0	214.0	269.0	1284.0	1811.0
WL	Innes Road (West)	L	136.0	142.0	155.0	351.3	465.0
WT		T	124.0	127.0	135.0	327.0	436.9
WR		R	113.0	112.6	113.0	253.0	359.0
All Movements		All	158.0	163.0	170.0	234.0	472.0

Method 1 Changed Rule							
Mean Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Papanui Road (North)	L	57.7	59.1	62.0	66.8	103.2
NT		T	60.5	62.2	64.9	69.0	104.8
NR		R	72.9	84.5	102.9	160.0	175.3
EL	Innes Road (East)	L	107.1	109.2	112.6	127.9	372.3
ET		T	104.6	106.7	108.4	124.3	369.5
ER		R	103.3	106.1	111.2	120.7	354.7
SL	Papanui Road (South)	L	154.2	155.8	158.5	426.0	614.9
ST		T	163.5	165.5	168.3	435.4	626.2
SR		R	169.3	185.0	296.2	1234.8	1413.4
WL	Innes Road (West)	L	95.7	99.3	111.5	185.6	295.6
WT		T	88.7	91.0	101.8	175.6	285.4
WR		R	82.4	82.7	86.2	136.5	218.5
All Movements		All	107.1	109.7	117.6	241.6	377.7
Median Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Papanui Road (North)	L	50.0	53.0	58.0	66.0	101.0
NT		T	52.0	56.0	62.0	68.0	102.0
NR		R	65.0	81.0	97.0	109.0	138.0
EL	Innes Road (East)	L	103.0	106.0	112.0	127.0	438.0
ET		T	103.0	106.0	108.0	125.0	431.0
ER		R	96.0	101.0	107.0	117.0	409.0
SL	Papanui Road (South)	L	147.0	149.0	153.0	294.0	434.0
ST		T	156.0	160.0	166.0	304.0	444.0
SR		R	163.0	179.0	269.0	1175.0	1043.0
WL	Innes Road (West)	L	90.0	97.0	110.0	139.0	277.0
WT		T	87.0	89.0	101.0	131.0	267.0
WR		R	73.0	76.0	82.0	106.0	198.0
All Movements		All	98.0	101.0	108.0	129.0	268.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Papanui Road (North)	L	46.0	47.0	47.0	48.0	67.0
NT		T	46.0	47.0	47.0	47.0	67.0
NR		R	50.0	53.0	59.0	55.0	92.0
EL	Innes Road (East)	L	74.0	78.0	79.0	93.0	181.0
ET		T	69.0	71.0	75.0	86.0	183.0
ER		R	80.0	81.0	84.0	90.0	165.0
SL	Papanui Road (South)	L	142.0	142.0	143.0	165.0	221.0
ST		T	148.0	148.0	150.0	174.0	233.0
SR		R	144.0	149.0	181.0	415.0	394.0
WL	Innes Road (West)	L	65.0	67.0	75.0	89.0	144.0
WT		T	53.0	56.0	64.0	79.0	134.0
WR		R	58.6	59.0	61.0	66.0	89.0
All Movements		All	51.0	53.0	58.0	65.0	96.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Papanui Road (North)	L	79.0	79.0	81.0	85.0	140.9
NT		T	83.0	85.0	87.0	90.0	144.0
NR		R	101.0	119.7	144.0	308.0	262.7
EL	Innes Road (East)	L	144.0	142.0	146.0	159.0	479.0
ET		T	141.0	142.0	142.0	157.0	478.0
ER		R	133.0	135.0	141.0	153.0	464.0
SL	Papanui Road (South)	L	176.0	177.0	178.0	825.0	1214.0
ST		T	187.0	188.0	191.0	839.0	1222.0
SR		R	201.0	221.0	415.0	2116.2	2833.9
WL	Innes Road (West)	L	131.0	133.0	145.0	345.0	436.6
WT		T	124.0	127.0	136.0	328.0	438.0
WR		R	113.0	112.6	113.0	251.0	359.0
All Movements		All	157.0	162.0	171.0	433.0	485.0

Method 2 Existing Rule							
Mean Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Papanui Road (North)	L	63.4	62.7	63.4	64.1	64.4
NT		T	62.9	62.2	61.9	61.7	60.5
NR		R	83.1	80.9	78.8	79.2	78.3
EL	Innes Road (East)	L	114.6	115.3	116.2	115.9	382.5
ET		T	108.2	106.7	106.3	105.4	367.4
ER		R	105.1	105.5	109.0	116.3	480.7
SL	Papanui Road (South)	L	159.0	158.5	157.9	157.6	158.8
ST		T	166.4	165.5	164.8	164.3	162.9
SR		R	175.7	179.1	181.4	181.4	184.2
WL	Innes Road (West)	L	107.2	107.5	109.4	109.3	106.9
WT		T	93.6	91.0	91.3	89.4	89.7
WR		R	82.0	82.6	83.2	83.3	85.0
All Movements		All	110.5	110.0	110.6	111.6	198.1
Median Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Papanui Road (North)	L	58.0	57.0	56.0	58.0	56.0
NT		T	57.0	56.0	55.0	54.0	50.0
NR		R	80.0	77.0	74.0	74.0	74.0
EL	Innes Road (East)	L	112.0	113.0	113.0	112.0	402.0
ET		T	108.0	106.0	105.0	104.0	394.0
ER		R	100.0	101.0	104.0	113.0	519.0
SL	Papanui Road (South)	L	153.0	152.0	151.0	151.0	152.0
ST		T	162.0	160.0	158.0	157.0	155.0
SR		R	170.0	173.0	176.0	178.0	182.0
WL	Innes Road (West)	L	104.0	104.0	106.0	108.0	105.0
WT		T	93.0	89.0	90.0	87.0	88.0
WR		R	77.0	76.0	76.0	76.0	79.0
All Movements		All	102.0	102.0	103.0	106.0	146.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Papanui Road (North)	L	49.0	49.0	49.0	49.0	49.0
NT		T	47.0	47.0	47.0	46.0	46.0
NR		R	52.0	51.0	50.0	51.0	51.0
EL	Innes Road (East)	L	81.0	82.0	79.0	82.0	140.0
ET		T	71.0	70.0	70.0	69.0	122.0
ER		R	80.0	81.0	83.0	87.0	193.0
SL	Papanui Road (South)	L	145.0	145.0	144.0	144.0	144.0
ST		T	148.0	148.0	148.0	148.0	148.0
SR		R	145.0	147.0	148.0	148.0	150.0
WL	Innes Road (West)	L	73.4	73.0	72.0	70.2	71.0
WT		T	58.0	55.0	54.0	54.0	53.0
WR		R	58.0	59.0	60.0	60.0	61.0
All Movements		All	53.0	53.0	54.0	55.0	57.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Papanui Road (North)	L	84.0	84.0	85.8	86.0	87.0
NT		T	86.0	85.0	85.0	85.0	84.0
NR		R	116.0	113.0	111.0	110.0	107.0
EL	Innes Road (East)	L	148.0	149.0	151.5	150.0	594.1
ET		T	143.0	142.0	142.0	141.0	583.1
ER		R	136.0	134.0	139.0	145.0	706.0
SL	Papanui Road (South)	L	179.0	179.0	179.0	177.0	179.0
ST		T	189.0	188.0	188.0	188.0	186.0
SR		R	208.0	214.0	216.0	214.0	215.0
WL	Innes Road (West)	L	141.0	142.0	147.0	146.9	144.0
WT		T	128.0	127.0	127.0	125.0	125.0
WR		R	111.0	112.6	114.0	113.0	115.0
All Movements		All	164.0	163.0	162.0	163.0	416.0

Method 2 Changed Rule							
Mean Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Papanui Road (North)	L	60.2	59.1	58.6	58.9	58.3
NT		T	62.9	62.2	61.9	61.7	60.7
NR		R	86.2	84.5	84.1	84.9	83.7
EL	Innes Road (East)	L	110.0	109.2	108.6	107.0	418.8
ET		T	108.2	106.7	106.3	105.4	415.4
ER		R	105.4	106.1	109.9	120.0	534.5
SL	Papanui Road (South)	L	156.8	155.8	154.8	154.6	154.6
ST		T	166.4	165.5	164.8	164.3	162.7
SR		R	178.3	185.0	190.3	191.1	205.6
WL	Innes Road (West)	L	102.1	99.3	98.0	98.5	95.5
WT		T	93.8	91.0	91.3	89.4	89.6
WR		R	82.3	82.7	83.6	83.9	85.4
All Movements		All	110.1	109.7	110.6	112.2	213.3
Median Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Papanui Road (North)	L	54.0	53.0	52.0	51.0	49.0
NT		T	57.0	56.0	54.0	54.0	51.0
NR		R	83.0	81.0	78.0	80.0	80.0
EL	Innes Road (East)	L	107.0	106.0	105.0	103.0	473.0
ET		T	108.0	106.0	105.0	104.0	467.0
ER		R	100.0	101.0	105.0	117.0	577.0
SL	Papanui Road (South)	L	151.0	149.0	148.0	148.0	147.0
ST		T	162.0	160.0	158.0	157.0	155.0
SR		R	174.0	179.0	185.0	187.0	198.0
WL	Innes Road (West)	L	100.0	97.0	94.0	95.0	91.0
WT		T	93.0	89.0	90.0	87.0	88.0
WR		R	77.0	76.0	77.0	77.0	80.0
All Movements		All	102.0	101.0	102.0	106.0	146.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Papanui Road (North)	L	47.0	47.0	47.0	47.0	47.0
NT		T	47.0	47.0	47.0	46.0	46.0
NR		R	53.0	53.0	52.0	52.0	52.0
EL	Innes Road (East)	L	78.0	78.0	74.4	75.0	128.4
ET		T	72.0	71.0	70.0	69.0	128.0
ER		R	80.1	81.0	84.0	89.0	222.0
SL	Papanui Road (South)	L	142.0	142.0	142.0	142.0	142.0
ST		T	148.0	148.0	148.0	148.0	148.0
SR		R	146.0	149.0	151.0	150.0	156.0
WL	Innes Road (West)	L	70.0	67.0	66.0	65.0	65.0
WT		T	58.0	56.0	55.0	54.0	53.0
WR		R	58.0	59.0	60.0	60.0	61.0
All Movements		All	53.0	53.0	53.0	55.0	57.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Papanui Road (North)	L	80.0	79.0	79.0	79.0	80.0
NT		T	86.0	85.0	85.0	85.0	84.0
NR		R	121.0	119.7	117.0	117.0	113.0
EL	Innes Road (East)	L	144.0	142.0	144.0	140.8	629.0
ET		T	142.1	142.0	142.0	141.0	627.0
ER		R	136.0	135.0	139.0	148.0	775.0
SL	Papanui Road (South)	L	177.0	177.0	175.0	175.0	175.0
ST		T	189.0	188.0	188.0	188.0	186.0
SR		R	213.0	221.0	227.0	228.0	251.0
WL	Innes Road (West)	L	136.7	133.0	132.0	134.0	131.0
WT		T	128.0	127.0	127.0	125.1	125.0
WR		R	111.0	112.6	114.0	114.0	116.0
All Movements		All	163.0	162.0	162.0	164.0	485.0

A8.7 Full Queue Length Analysis Results

Method 1							
Existing Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Papanui Road (North)	L	1.2	1.2	1.4	1.6	1.8
N2		T	3.2	4.5	5.9	10.8	17.0
N3		R	1.1	1.2	1.4	3.5	8.3
E1	Innes Road (East)	L	1.3	1.5	1.6	1.9	2.0
E2		T	3.1	4.2	5.3	9.8	24.4
E3		R	1.5	1.8	2.2	3.0	4.5
S1	Papanui Road (South)	L	1.2	1.3	1.4	1.6	1.7
S2		T	3.3	4.5	5.7	11.2	19.9
S3		R	1.2	1.5	2.6	19.8	25.9
W1	Innes Road (West)	L	1.2	1.3	1.5	1.6	1.8
W2		T	3.3	4.3	6.3	11.5	23.5
W3		R	1.3	1.4	1.5	1.7	2.0
Maximum Queue Length (vehicles)							
Queue	Approach		**75**	**100**	**125**	**150**	**175**
N1	Papanui Road (North)	L	1.4	1.5	1.9	2.2	2.3
N2		T	6.0	8.3	11.3	20.6	31.3
N3		R	1.2	1.5	1.9	4.5	9.4
E1	Innes Road (East)	L	1.7	2.1	2.3	2.7	2.8
E2		T	6.2	8.4	10.8	17.4	55.4
E3		R	2.7	3.6	4.7	6.3	8.8
S1	Papanui Road (South)	L	1.5	1.6	1.8	2.1	2.2
S2		T	6.1	8.3	10.8	23.3	45.8
S3		R	1.6	2.1	3.9	22.1	28.1
W1	Innes Road (West)	L	1.4	1.8	2.1	2.2	2.4
W2		T	6.4	8.7	12.1	21.0	44.8
W3		R	1.6	1.9	2.4	2.9	3.7
Changed Rule							
Average Queue Length (vehicles)							
Queue	Approach		**75**	**100**	**125**	**150**	**175**
N1	Papanui Road (North)	L	1.2	1.3	1.4	1.4	1.7
N2		T	3.2	4.5	5.9	7.7	12.6
N3		R	1.1	1.2	1.5	3.4	3.7
E1	Innes Road (East)	L	1.3	1.4	1.5	1.7	1.9
E2		T	3.1	4.2	5.3	8.8	24.0
E3		R	1.5	1.8	2.2	2.9	4.6
S1	Papanui Road (South)	L	1.3	1.3	1.4	1.5	1.5
S2		T	3.3	4.5	5.6	19.5	29.1
S3		R	1.2	1.6	5.3	30.6	35.6
W1	Innes Road (West)	L	1.2	1.3	1.4	1.5	1.7
W2		T	3.3	4.3	6.3	11.3	23.3
W3		R	1.2	1.4	1.5	1.6	2.1
Maximum Queue Length (vehicles)							
Queue	Approach		**75**	**100**	**125**	**150**	**175**
N1	Papanui Road (North)	L	1.4	1.5	1.8	1.9	2.2
N2		T	6.0	8.3	11.2	14.8	25.4
N3		R	1.2	1.5	2.1	4.2	4.5
E1	Innes Road (East)	L	1.7	2.0	2.1	2.3	2.5
E2		T	6.2	8.4	10.7	16.0	55.0
E3		R	2.7	3.6	4.8	6.2	9.1
S1	Papanui Road (South)	L	1.6	1.6	1.8	1.9	1.8
S2		T	6.1	8.3	10.8	44.5	72.3
S3		R	1.6	2.3	6.9	32.5	37.0
W1	Innes Road (West)	L	1.4	1.6	1.9	2.0	2.3
W2		T	6.4	8.7	12.0	20.6	44.3
W3		R	1.6	1.9	2.4	2.8	4.0

Method 2							
Existing Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Papanui Road (North)	L	1.3	1.2	1.2	1.3	1.2
N2		T	4.8	4.5	4.1	3.8	3.1
N3		R	1.1	1.2	1.4	1.6	1.9
E1	Innes Road (East)	L	1.4	1.5	1.5	1.4	1.3
E2		T	4.6	4.2	3.9	3.5	17.1
E3		R	1.4	1.8	2.5	3.4	15.3
S1	Papanui Road (South)	L	1.3	1.3	1.3	1.2	1.2
S2		T	4.9	4.5	4.2	3.7	3.0
S3		R	1.2	1.5	1.9	2.4	3.4
W1	Innes Road (West)	L	1.4	1.3	1.4	1.4	1.3
W2		T	4.8	4.3	4.1	3.7	3.1
W3		R	1.1	1.4	1.6	1.8	2.3
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Papanui Road (North)	L	1.7	1.5	1.5	1.6	1.5
N2		T	9.0	8.3	7.7	6.9	5.4
N3		R	1.2	1.5	1.8	2.4	3.1
E1	Innes Road (East)	L	1.9	2.1	2.0	1.8	1.7
E2		T	9.3	8.4	7.7	7.1	45.8
E3		R	2.1	3.6	5.5	7.7	21.4
S1	Papanui Road (South)	L	1.6	1.6	1.6	1.5	1.4
S2		T	9.3	8.3	7.6	6.8	5.2
S3		R	1.4	2.1	3.1	4.0	6.1
W1	Innes Road (West)	L	1.8	1.8	1.8	1.7	1.6
W2		T	9.8	8.7	8.1	7.3	6.1
W3		R	1.3	1.9	2.7	3.3	4.9
Changed Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Papanui Road (North)	L	1.4	1.3	1.2	1.3	1.2
N2		T	4.8	4.5	4.1	3.8	3.1
N3		R	1.1	1.2	1.4	1.7	2.1
E1	Innes Road (East)	L	1.4	1.4	1.5	1.3	1.3
E2		T	4.6	4.2	3.9	3.5	18.0
E3		R	1.4	1.8	2.5	3.6	15.6
S1	Papanui Road (South)	L	1.3	1.3	1.3	1.2	1.2
S2		T	4.9	4.5	4.2	3.7	3.0
S3		R	1.2	1.6	2.2	2.8	5.2
W1	Innes Road (West)	L	1.4	1.3	1.3	1.3	1.2
W2		T	4.8	4.3	4.1	3.7	3.1
W3		R	1.2	1.4	1.6	1.8	2.3
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Papanui Road (North)	L	1.8	1.5	1.5	1.5	1.4
N2		T	9.0	8.3	7.7	6.9	5.4
N3		R	1.2	1.5	2.0	2.6	3.4
E1	Innes Road (East)	L	1.8	2.0	1.9	1.7	1.6
E2		T	9.4	8.4	7.7	7.1	49.6
E3		R	2.1	3.6	5.5	8.1	21.7
S1	Papanui Road (South)	L	1.7	1.6	1.7	1.5	1.4
S2		T	9.2	8.3	7.6	6.8	5.2
S3		R	1.4	2.3	3.5	4.6	8.3
W1	Innes Road (West)	L	1.7	1.6	1.6	1.6	1.4
W2		T	9.7	8.7	8.1	7.3	6.1
W3		R	1.3	1.9	2.7	3.4	5.0

APPENDIX A9

Intersection 7 – Blenheim Road/Matipo Street

Full Data

Table of Contents

A9.1 Approach Photos

Figure A9.1.1 - Matipo Street North Approach

Figure A9.1.2 - Blenheim Road East Approach

Figure A9.1.3 - Matipo Street South Approach

Figure A9.1.4 - Blenheim Road West Approach

A9.2 Surveyed Traffic Volume Data

Intersection 7: Blenheim Road/Matipo Street

Survey Date Tuesday, 14 November 2006

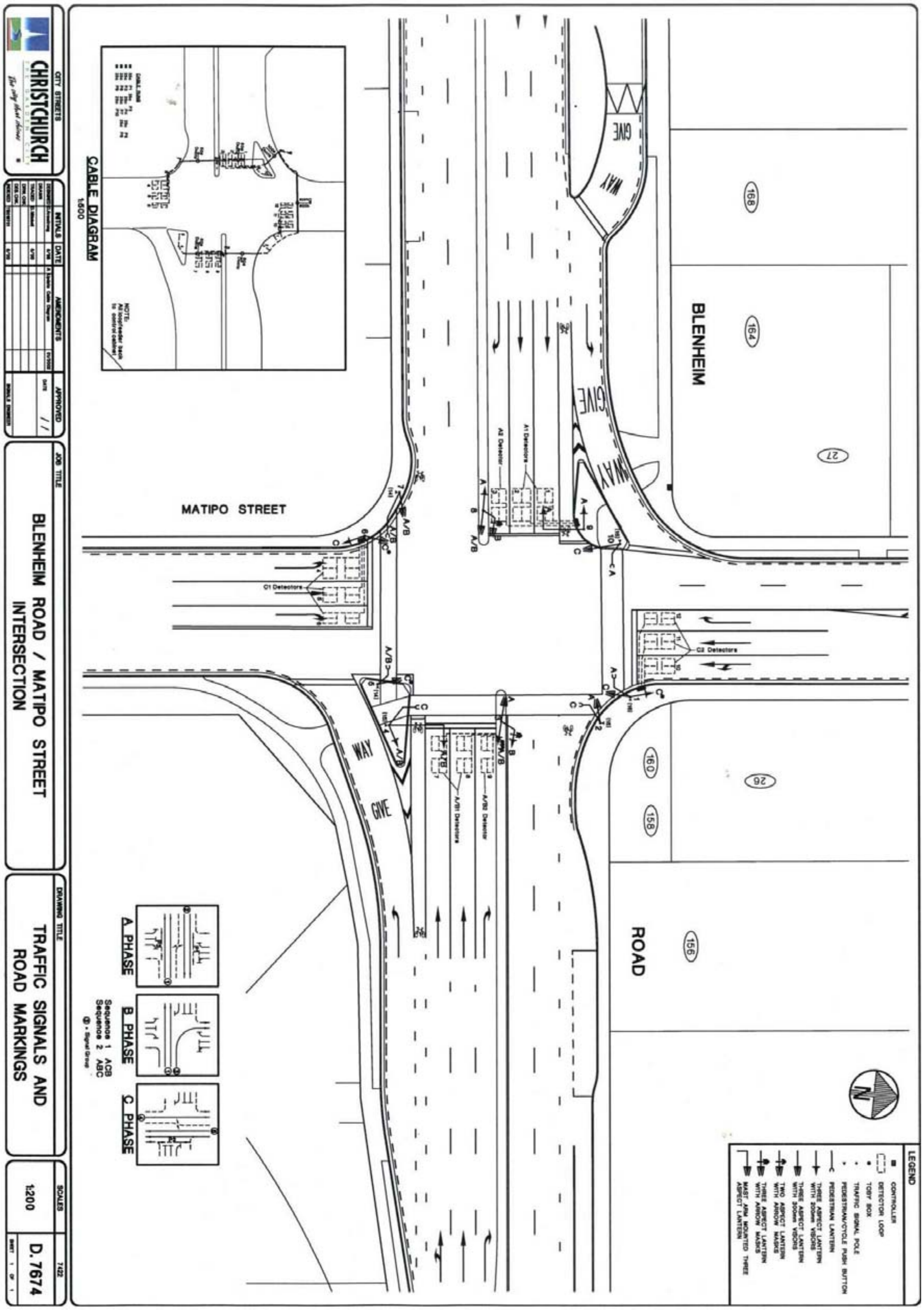
Light Vehicles			Matipo (South)			Blenheim (East)			Matipo (North)			Blenheim (West)			TOTAL
			L	T	R	L	T	R	L	T	R	L	T	R	
2:30	-	2:45	27	47	34	32	75	20	26	67	29	22	92	21	492
2:45	-	3:00	37	51	0	26	95	15	37	78	36	27	101	3	506
3:00	-	3:15	36	36	24	39	213	16	16	42	36	23	123	21	625
3:15	-	3:30	24	48	22	32	110	27	25	43	29	17	146	36	559
3:30	-	3:45	38	68	44	42	232	20	33	64	25	20	123	32	741
3:45	-	4:00	42	57	43	30	240	35	22	61	27	23	111	38	729

Heavy Vehicles			Matipo (South)			Blenheim (East)			Matipo (North)			Blenheim (West)			TOTAL
			L	T	R	L	T	R	L	T	R	L	T	R	
2:30	-	2:45	11	8	3	2	20	3	1	2	0	2	6	1	59
2:45	-	3:00	12	12	7	2	21	9	1	0	1	0	3	0	68
3:00	-	3:15	11	7	1	4	12	0	1	2	2	1	1	0	42
3:15	-	3:30	2	2	2	5	14	9	0	1	1	2	3	1	42
3:30	-	3:45	5	0	1	4	17	1	0	0	2	0	4	0	34
3:45	-	4:00	10	4	7	1	15	5	1	3	1	2	2	1	52

Total	Matipo (South)			Blenheim (East)			Matipo (North)			Blenheim (West)		
(2:30pm - 4:00pm)	L	T	R	L	T	R	L	T	R	L	T	R
Light	204	307	167	201	965	133	159	355	182	132	696	151
Heavy	51	33	21	18	99	27	4	8	7	7	19	3

Peak Hour	Matipo (South)			Blenheim (East)			Matipo (North)			Blenheim (West)		
(2:45pm - 3:45pm)	L	T	R	L	T	R	L	T	R	L	T	R
Light	135	203	90	139	650	78	111	227	126	87	493	92
Heavy	30	21	11	15	64	19	2	3	6	3	11	1

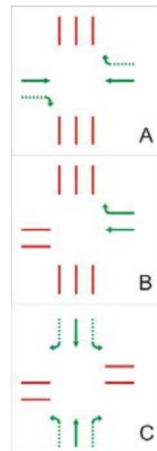
A9.3 Traffic Signal Plan



A9.4 Observed and Modelled Signal Timings

Intersection 7 Blenheim Road/Matipo Street (SCATS ID = 422)

Traffic Count Day		Tuesday 14 November, 2006		
Observed Signal Day		Tuesday 10 October, 2006		
Observed Time Period		2:30pm to 4:00pm		
Observed Phase Timings				
Phase	Count	Minimum (s)	Maximum (s)	Average (s)
A	45	32	103	61
B	43	16	29	19
C	45	23	53	40
Cycle	-	-	-	120
Modelled Phase Timings				
A	-	-	-	49
B	-	-	-	18
C	-	-	-	53
Cycle	-	-	-	120



A9.5 Results Summary

A9.5.1 Journey Times Method 1

Figure A9.5.1 and Figure A9.5.2 present the average journey times for the two right turn movements at the intersection. Both have separate right turn lanes.

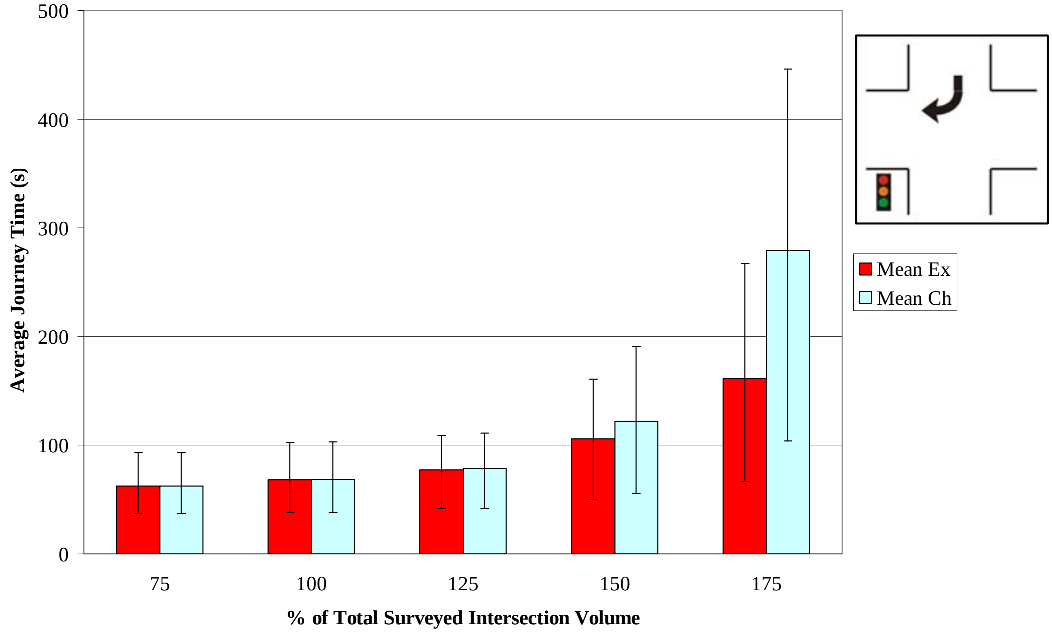


Figure A9.5.1 - Intersection 7, M1, Matipo Street (North) Right Turn Journey Time Comparison

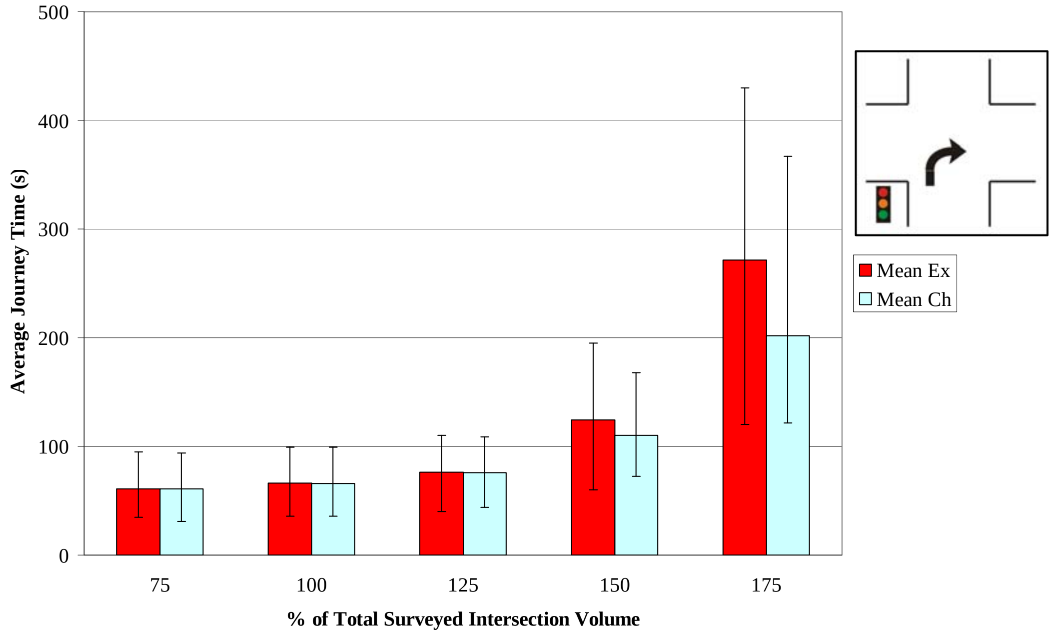


Figure A9.5.2 - Intersection 7, M1, Matipo Street (South) Right Turn Journey Time Comparison

Figure A9.5.3 and Figure A9.5.4 present the average journey times for the two left turn movements at the intersection. Both have separate left turn lanes.

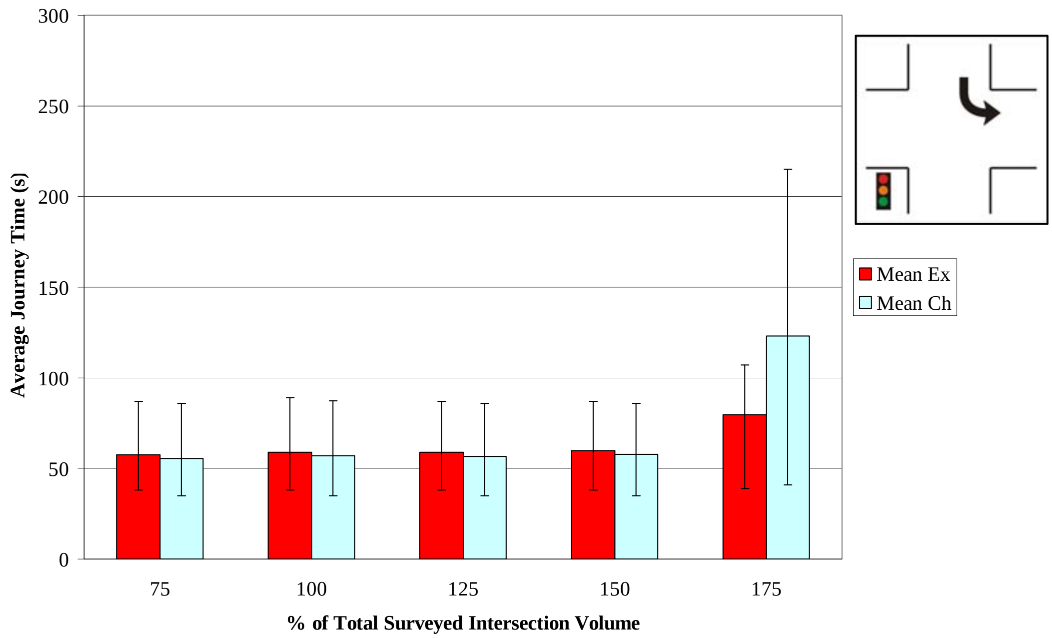


Figure A9.5.3 - Intersection 7, M1, Matipo Street (North) Left Turn Journey Time Comparison

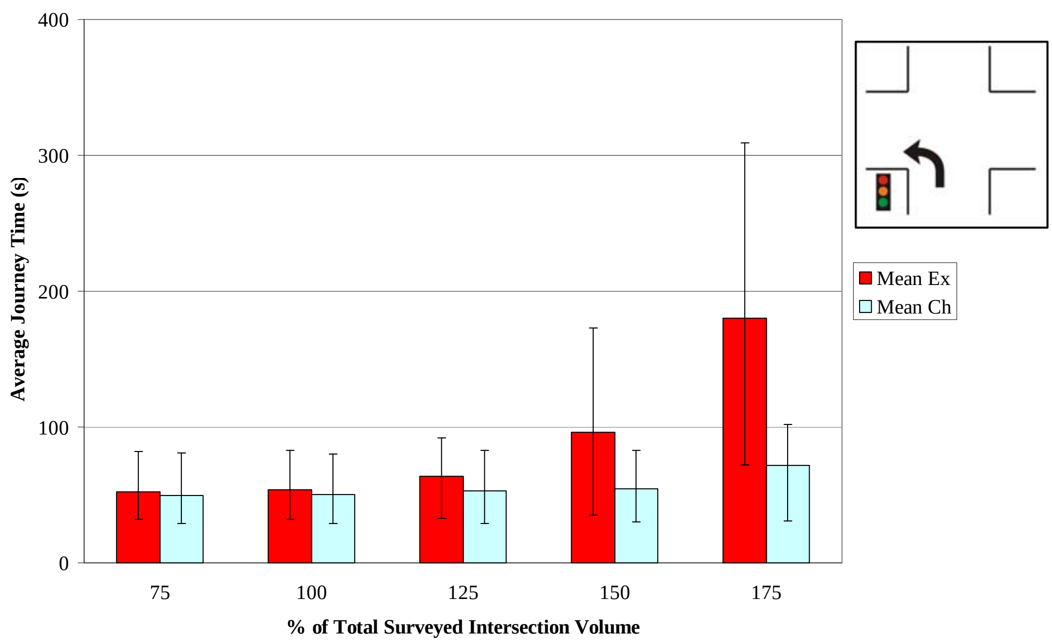


Figure A9.5.4 - Intersection 7, M1, Matipo Street (South) Left Turn Journey Time Comparison

Figure A9.5.5 shows the average journey time for all movements through the intersection under each rule.

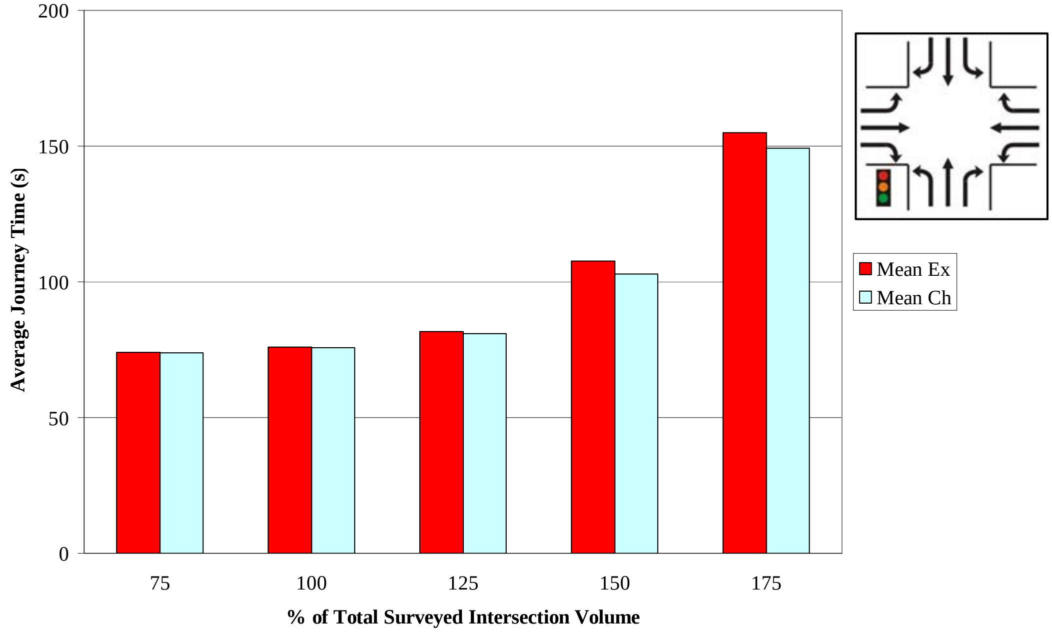


Figure A9.5.5 - Intersection 7, M1, Total Intersection Journey Time Comparison

A9.5.2 Journey Times Method 2

Figure A9.5.6 and Figure A9.5.7 present the average journey times for the two right turn movements from the Matipo Street approaches. Both have separate right turn lanes.

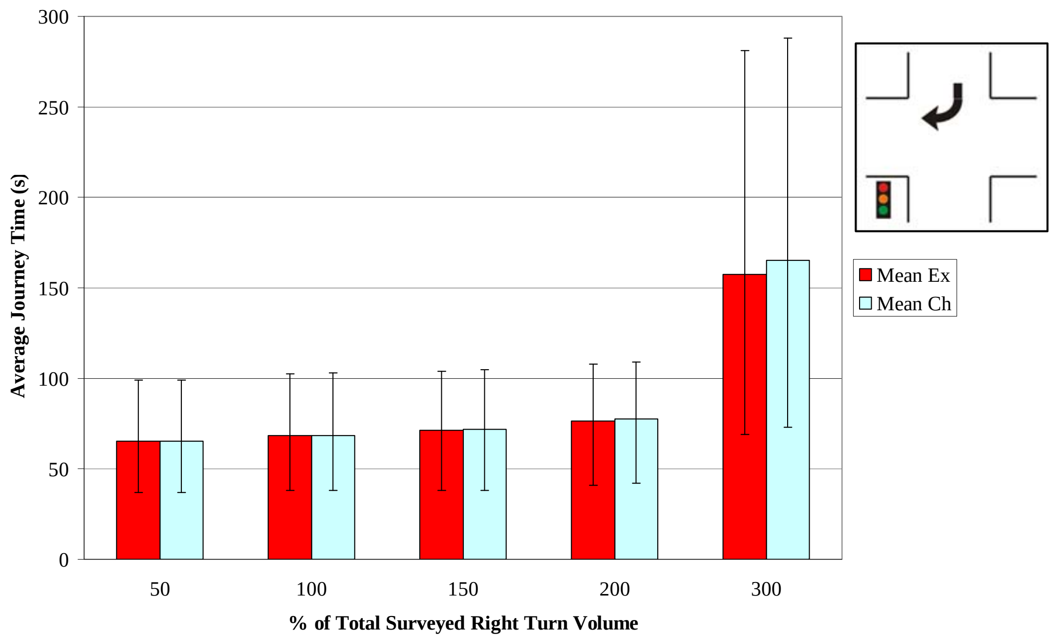


Figure A9.5.6 - Intersection 7, M2, Matipo Street (North) Right Turn Journey Time Comparison

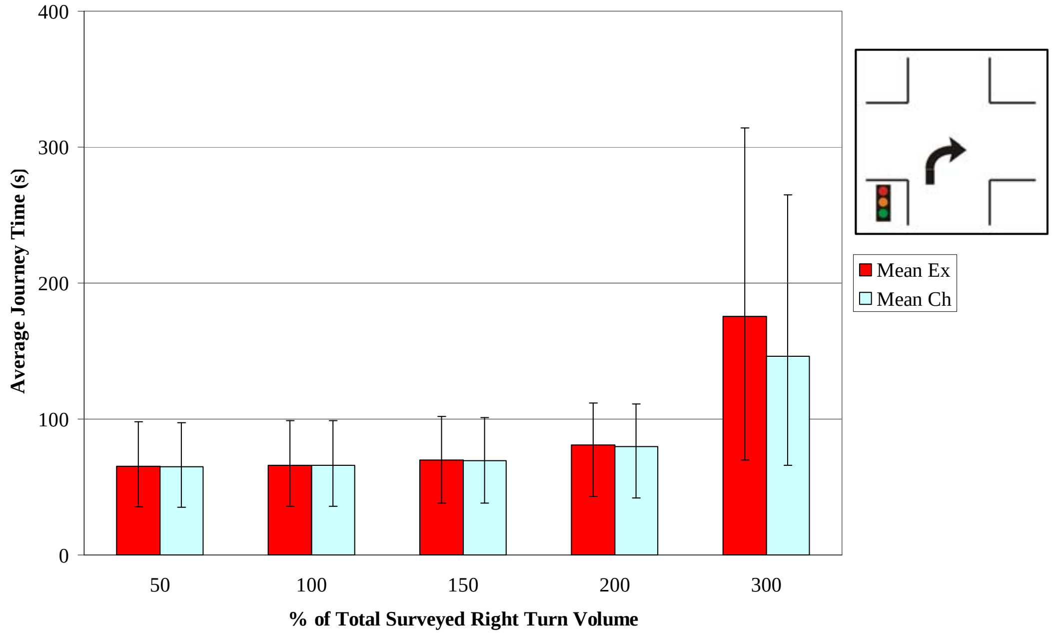


Figure A9.5.7 - Intersection 7, M2, Matipo Street (South) Right Turn Journey Time Comparison

Figure A9.5.7 and Figure A9.5.8 present the average journey times for the two left turn movements from the Matipo Street approaches. Both have separate left turn lanes.

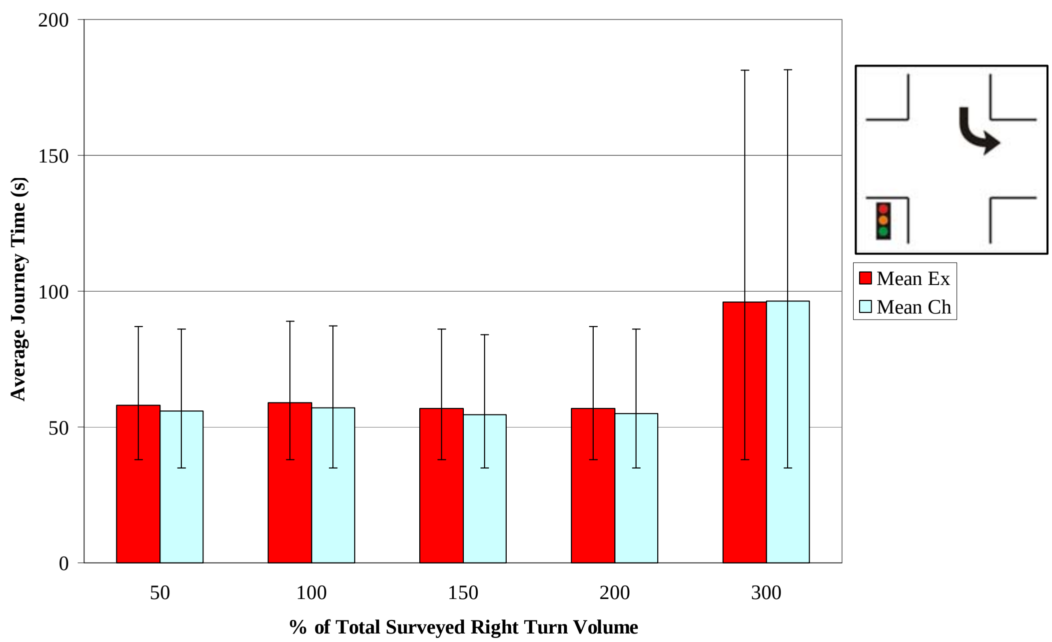


Figure A9.5.8 - Intersection 7, M2, Matipo Street (North) Left Turn Journey Time Comparison

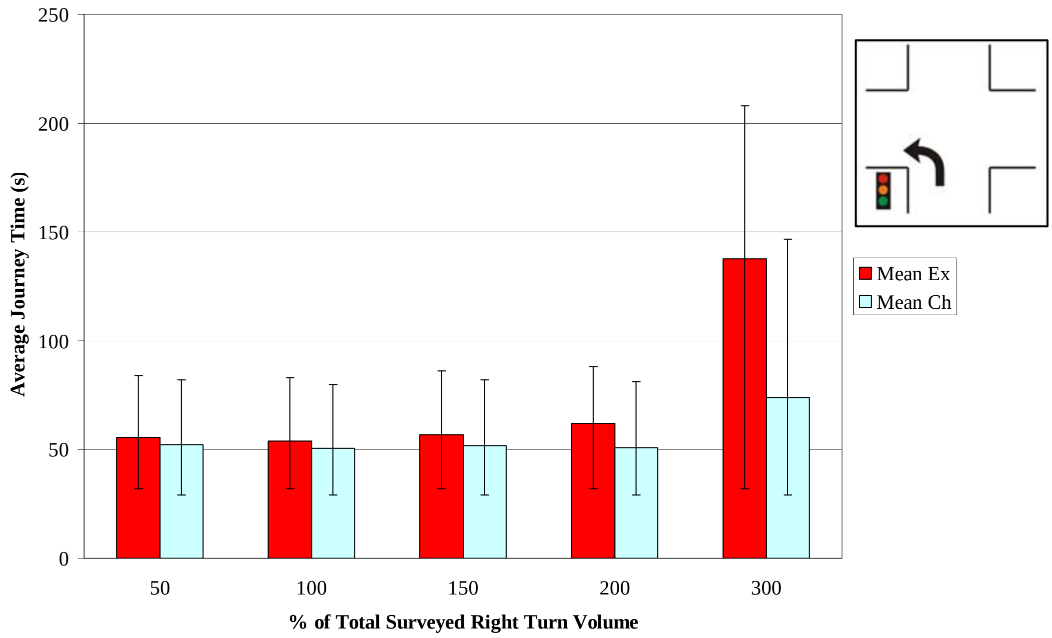


Figure A9.5.9 - Intersection 7, M2, Matipo Street (South) Left Turn Journey Time Comparison

Figure A9.5.10 shows the average journey time for all movements through the intersection under each rule.

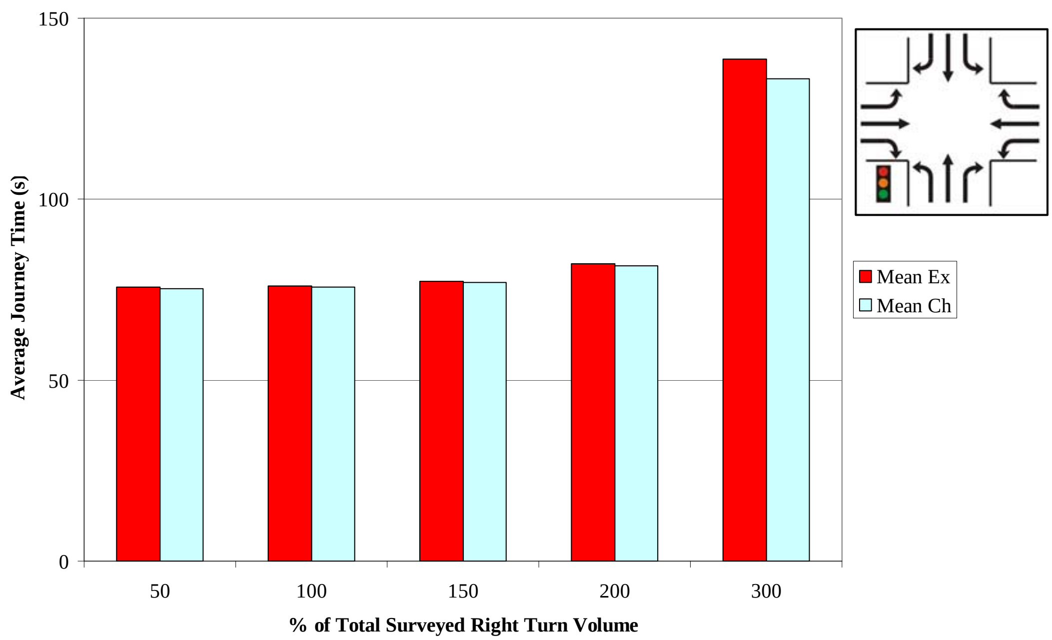


Figure A9.5.10 - Intersection 7, M2, Total Intersection Journey Time Comparison

Table A9.5.1 summarises the average journey time for all movements for each volume scenario.

Table A9.5.1 - Intersection 7, M2, Average Journey Time Comparison

Approach	Mvt	Average Journey Time (seconds/vehicle) for Various % Scenarios									
		50%		100%		150%		200%		300%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Matipo Street (North)	L	58	56	59	57	57	55	57	55	96	96
	T	54	54	55	55	55	55	54	54	92	96
	R	65	65	68	69	71	72	77	78	157	165
Blenheim Road (East)	L	88	88	87	87	87	87	87	87	86	86
	T	87	87	86	86	86	86	85	85	84	85
	R	87	86	86	86	87	87	88	88	90	91
Matipo Street (South)	L	56	52	54	50	57	52	62	51	138	74
	T	51	51	51	51	50	50	52	50	104	74
	R	65	65	66	66	70	70	81	80	176	146
Blenheim Road (West)	L	70	70	70	70	70	70	70	70	71	71
	T	90	90	89	89	90	89	89	89	90	90
	R	98	98	105	106	110	111	142	145	311	320
Total	All	76	75	76	76	77	77	82	82	139	133

The table shows that there is very little difference between the overall average journey time for all movements through intersection as a result of the rule change to nearside priority. A difference of some 6 seconds/vehicle arises at the 300% scenario where the changed rule appears more efficient.

Table A9.5.2 presents a summary of the increase or decrease in journey time for these two movements as a result of the rule change to nearside priority.

Table A9.5.2 - Intersection 7, M2, Right and Left Turn Journey Time Changes

Movement	Change in Average Journey Time (seconds/vehicle) for Various % Scenarios				
	50%	100%	150%	200%	300%
Matipo Street (North) R	0.2	0.1	0.5	1.0	7.7
Matipo Street (South) L	-3.4	-3.4	-5.1	-11.3	-63.6
Matipo Street (South) R	-0.3	-0.2	-0.4	-1.2	-29.3
Matipo Street (North) L	-2.2	-2.0	-2.4	-2.0	0.4

The tables show that there are decreases in left turn journey time of 2 to 11 seconds/vehicle for the first four scenarios with a slight increase in right turn journey time, less than 1 second/vehicle observed on the north approach. As discussed in Section 5.7.1, the south approach is affected by the blocking of the north approach and therefore shows journey time decreases as it operates unopposed for much of the time.

A9.5.3 Queue Lengths Method 1

Figure A9.5.11 and Figure A9.5.12 present queue length comparisons for the two right turn movements from the Matipo Street approaches. Both have separate right turn lanes.

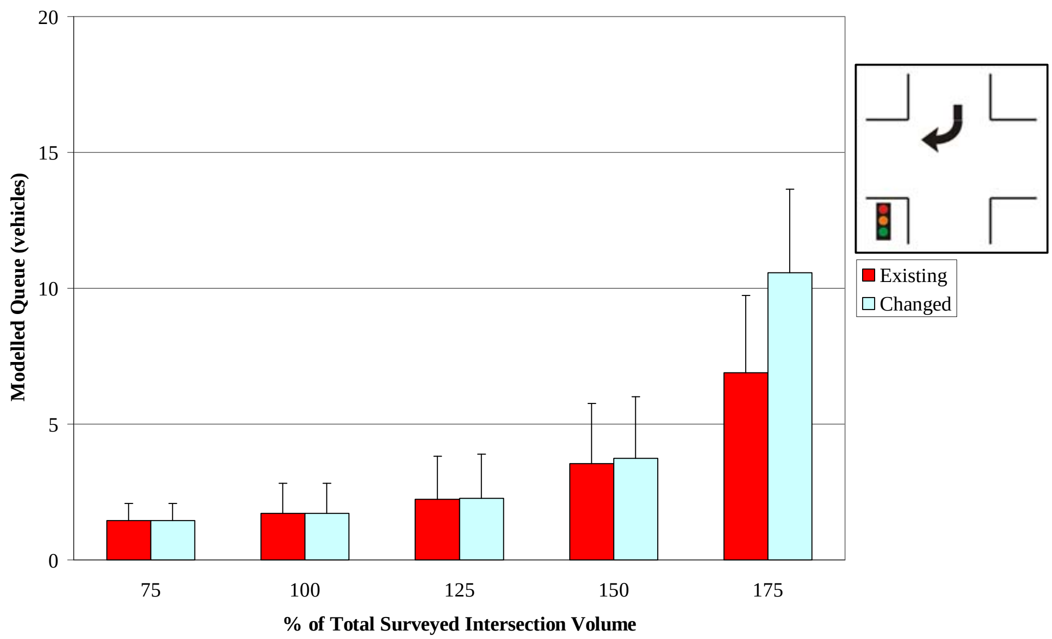


Figure A9.5.11 - Intersection 7, M1, Matipo Street (North) Right Turn Queue Comparison

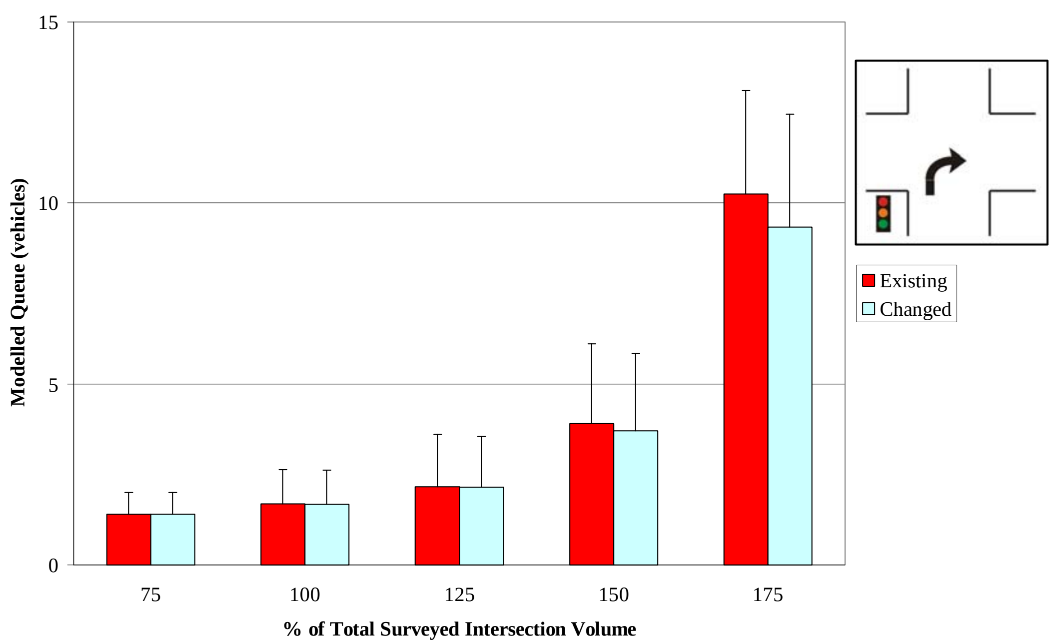


Figure A9.5.12 - Intersection 7, M1, Matipo Street (South) Right Turn Queue Comparison

Figure A9.5.13 and Figure A9.5.14 present queue length comparisons for the two left turn movements from the Matipo Street approaches. Both have separate left turn lanes.

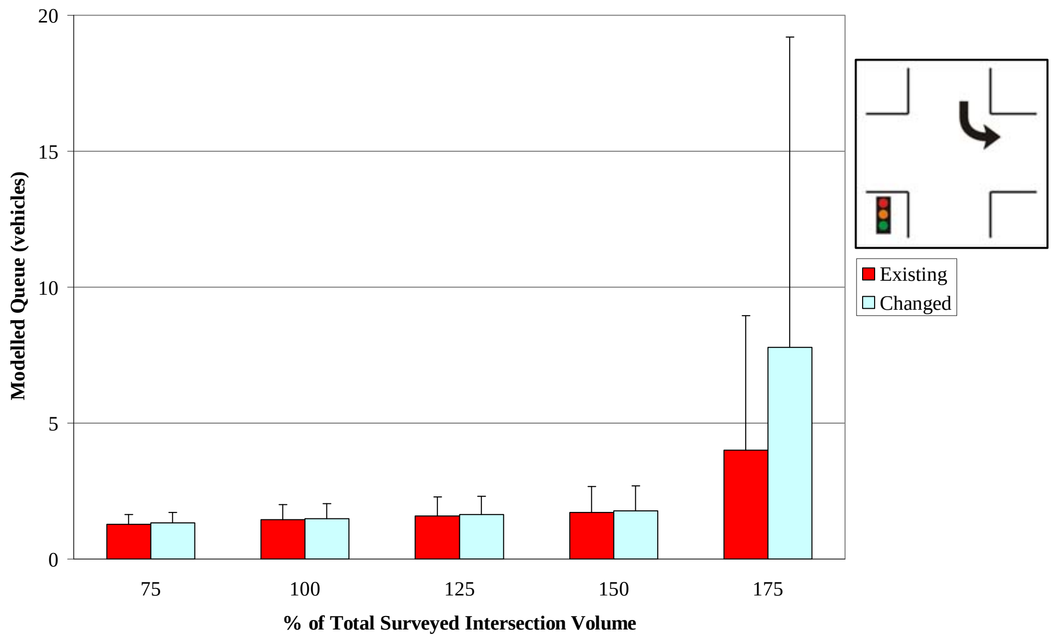


Figure A9.5.13 - Intersection 7, M1, Matipo Street (North) Left Turn Queue Comparison

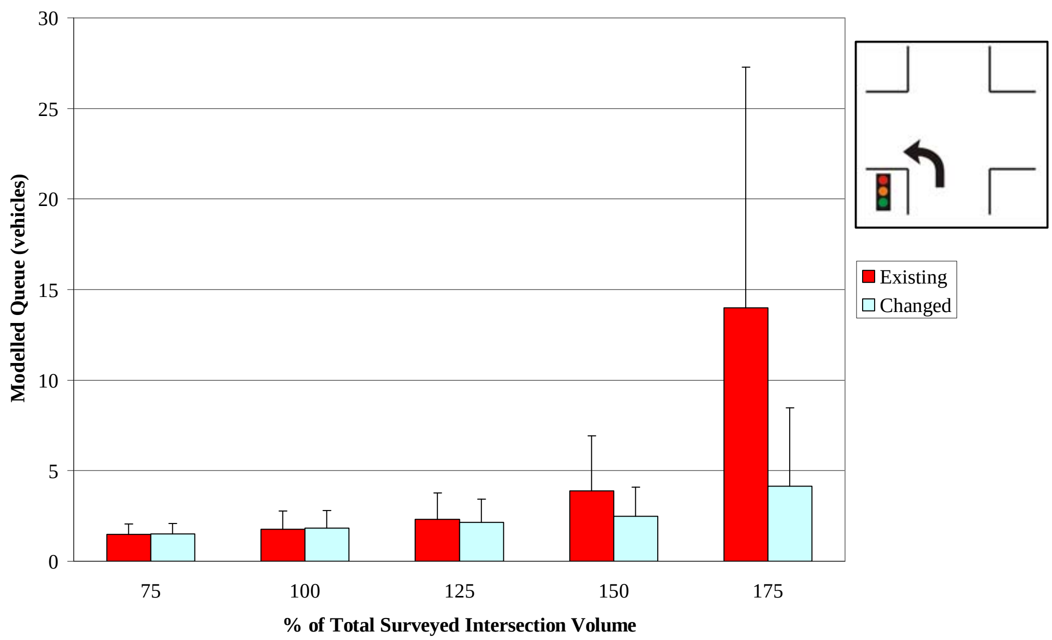


Figure A9.5.14 - Intersection 7, M1, Matipo Street (South) Left Turn Queue Comparison

A9.5.4 Queue Lengths Method 2

Figure A9.5.15 and Figure A9.5.16 present queue length comparisons for the two right turn movements from the Matipo Street approaches. Both have separate right turn lanes.

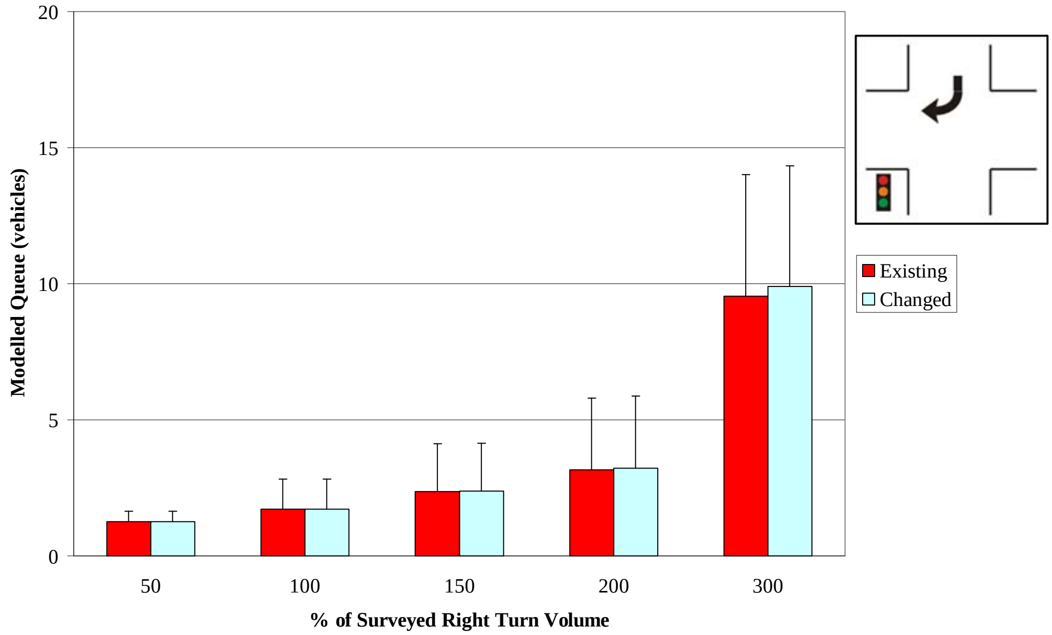


Figure A9.5.15 - Intersection 7, M2, Matipo Street (North) Right Turn Queue Comparison

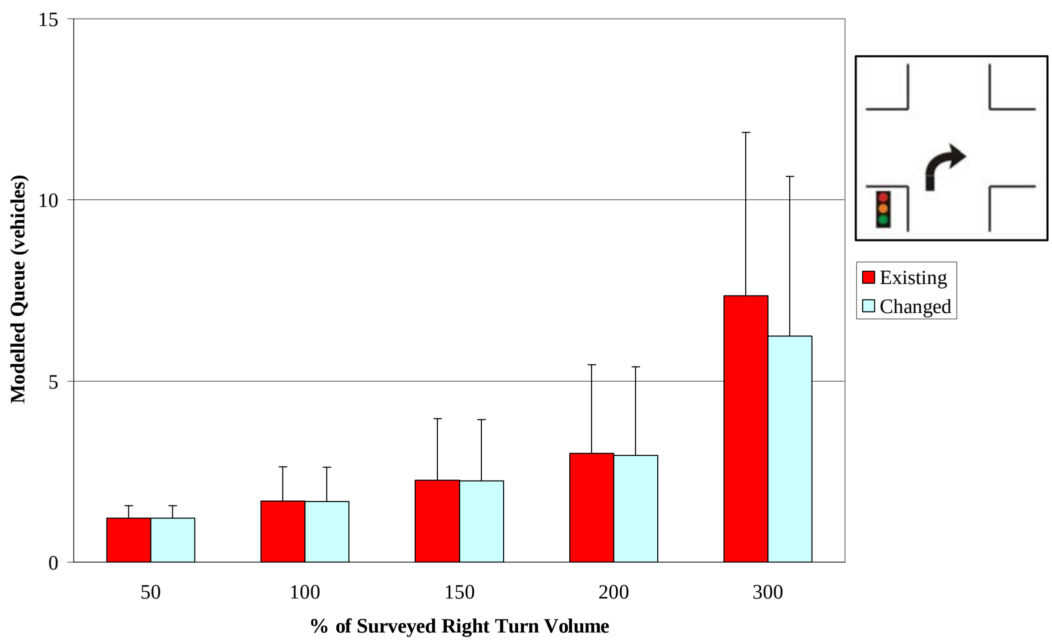


Figure A9.5.16 - Intersection 7, M2, Matipo Street (South) Right Turn Queue Comparison

Figure A9.5.17 and Figure A9.5.18 present queue length comparisons for the two left turn movements from the Matipo Street approaches. Both have separate left turn lanes.

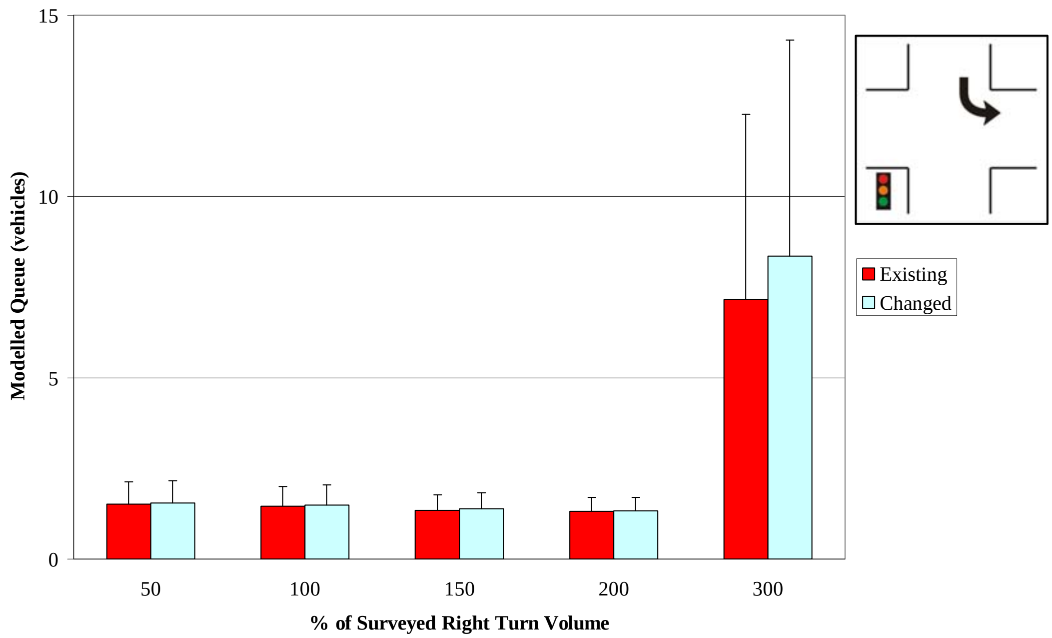


Figure A9.5.17 - Intersection 7, M2, Matipo Street (North) Left Turn Queue Comparison

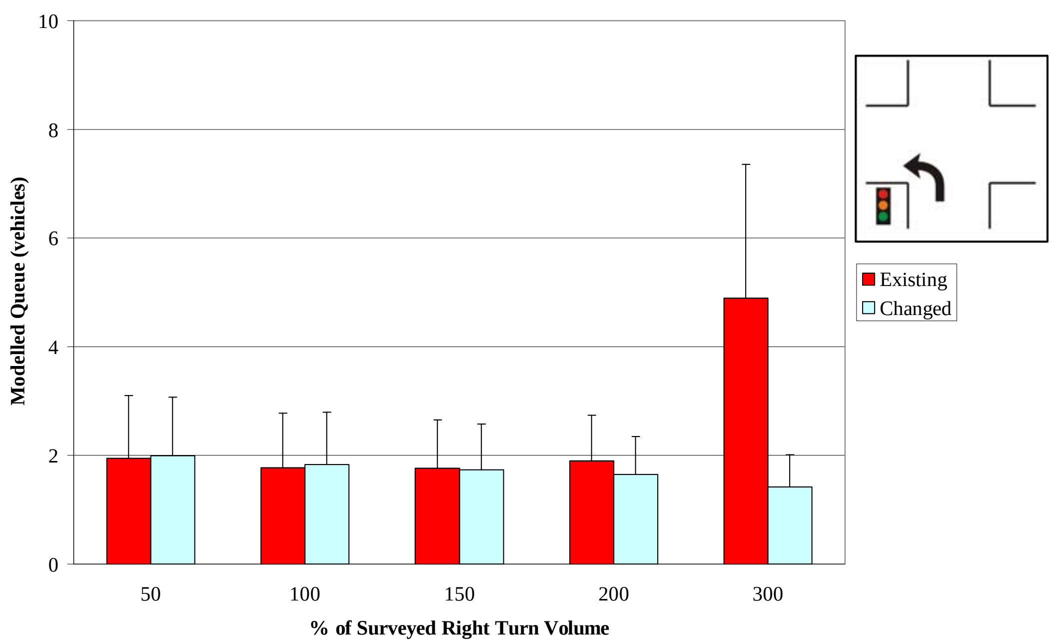


Figure A9.5.18 - Intersection 7, M2, Matipo Street (South) Left Turn Queue Comparison

Table A9.5.3 summarises the average queue lengths for each volume scenario.

Table A9.5.3 - Intersection 7, M2, Average Queue Comparison

Approach	Mvt	Average Queue Length (vehicles) for Various % Scenarios									
		50%		100%		150%		200%		300%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Matipo Street (North)	L	1.5	1.6	1.5	1.5	1.4	1.4	1.3	1.3	7.1	8.4
	T	2.7	2.7	2.6	2.6	2.4	2.4	2.1	2.1	1.9	1.9
	R	1.3	1.3	1.7	1.7	2.4	2.4	3.2	3.2	9.5	9.9
Blenheim Road (East)	L	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.0
	T	3.9	3.9	3.7	3.7	3.3	3.3	3.0	3.0	2.4	2.3
	T	3.3	3.3	2.9	2.9	2.7	2.7	2.2	2.2	1.7	1.8
	R	1.1	1.1	1.4	1.4	1.7	1.7	2.2	2.2	2.8	2.9
Matipo Street (South)	L	1.9	2.0	1.8	1.8	1.8	1.7	1.9	1.7	4.9	1.4
	T	2.4	2.4	2.2	2.2	2.1	2.1	2.1	1.9	2.5	1.6
	R	1.2	1.2	1.7	1.7	2.3	2.2	3.0	2.9	7.4	6.2
Blenheim Road (West)	L	1.0	1.0	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0
	T	3.4	3.4	3.0	3.1	2.9	2.9	2.6	2.6	2.1	2.0
	T	2.7	2.7	2.4	2.4	2.2	2.2	2.0	2.0	7.5	8.2
	R	1.3	1.3	1.9	1.9	2.4	2.4	3.9	3.9	7.7	7.7

The analysis shows that on Matipo Street (North) the right turn queue length increases slightly and there decrease of a similar size in left turn queue length. On Matipo Street (South) there is also an increase in right turn queue length and a more obvious reduction in left turn queue length. On Matipo Street (South) there is a reduction in both right and left turn queue lengths however this is due to the blocking of the north approach as discussed in Section 5.7.1.

A9.6 Full Journey Time Analysis Results

Method 1 Existing Rule							
Mean Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Matipo Street (North)	L	57.4	59.0	58.9	59.8	79.5
NT		T	54.8	55.4	56.3	57.0	75.4
NR		R	62.4	68.4	77.3	105.8	161.5
EL	Blenheim Road (East)	L	86.3	87.3	89.0	91.6	95.5
ET		T	85.2	86.1	87.3	88.8	90.3
ER		R	85.6	86.2	88.6	92.9	98.5
SL	Matipo Street (South)	L	52.2	53.9	63.8	96.2	180.1
ST		T	49.8	51.0	53.0	72.9	141.3
SR		R	61.2	66.2	76.5	124.3	271.4
WL	Blenheim Road (West)	L	69.1	70.3	72.3	79.4	109.8
WT		T	87.8	88.9	90.5	99.6	129.0
WR		R	93.9	105.0	181.2	592.8	1032.4
All Movements		All	74.1	76.0	81.6	107.7	155.0
Median Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Matipo Street (North)	L	48.0	52.0	53.0	55.0	68.0
NT		T	48.0	48.0	51.0	53.0	66.0
NR		R	58.0	65.0	77.0	96.0	136.0
EL	Blenheim Road (East)	L	85.0	86.0	87.0	88.0	91.0
ET		T	75.0	78.0	81.0	84.0	88.0
ER		R	78.0	80.0	84.0	90.0	96.0
SL	Matipo Street (South)	L	44.0	48.0	57.0	73.0	150.0
ST		T	42.0	45.0	48.0	61.0	127.0
SR		R	55.0	62.0	75.0	111.0	257.0
WL	Blenheim Road (West)	L	68.0	69.0	70.0	74.0	79.0
WT		T	81.0	84.0	86.0	93.0	97.0
WR		R	89.0	100.0	147.0	516.0	991.0
All Movements		All	71.0	73.0	76.0	84.0	94.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Matipo Street (North)	L	38.0	38.0	38.0	38.0	39.0
NT		T	32.0	32.0	32.0	32.0	32.0
NR		R	37.0	38.0	42.0	50.0	67.0
EL	Blenheim Road (East)	L	84.0	84.0	84.0	85.0	85.0
ET		T	69.0	69.0	69.0	70.0	70.0
ER		R	72.0	72.0	73.0	75.0	77.0
SL	Matipo Street (South)	L	32.0	32.0	33.0	35.0	72.0
ST		T	28.0	28.0	28.0	28.0	60.1
SR		R	35.0	36.0	40.0	60.0	120.0
WL	Blenheim Road (West)	L	67.0	67.0	67.0	68.0	69.0
WT		T	63.0	64.0	64.0	65.0	66.0
WR		R	67.0	69.0	83.0	108.0	137.0
All Movements		All	39.0	42.0	47.0	57.0	68.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Matipo Street (North)	L	87.0	89.0	87.0	87.0	107.0
NT		T	86.0	87.0	87.0	87.4	101.0
NR		R	93.0	102.6	109.0	160.8	267.0
EL	Blenheim Road (East)	L	89.0	90.0	94.0	101.0	108.0
ET		T	110.0	112.0	112.0	113.0	114.0
ER		R	107.0	107.0	109.0	114.0	119.3
SL	Matipo Street (South)	L	82.0	83.0	92.0	173.0	309.0
ST		T	81.0	82.0	83.0	98.0	225.0
SR		R	95.0	99.0	110.0	195.0	430.0
WL	Blenheim Road (West)	L	72.0	74.0	79.0	89.0	101.0
WT		T	120.0	120.0	123.0	128.0	133.0
WR		R	126.0	138.0	303.0	1170.0	1897.0
All Movements		All	102.0	105.0	110.0	121.0	165.0

Method 1 Changed Rule							
Mean Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Matipo Street (North)	L	55.4	57.0	56.7	57.9	123.0
NT		T	54.8	55.4	56.3	57.5	122.6
NR		R	62.5	68.5	78.6	122.3	279.2
EL	Blenheim Road (East)	L	86.2	87.4	88.9	91.4	94.7
ET		T	85.1	86.2	87.3	89.0	90.5
ER		R	85.6	86.4	88.4	92.0	98.1
SL	Matipo Street (South)	L	49.8	50.5	53.1	54.5	71.9
ST		T	49.8	50.9	51.8	53.4	71.0
SR		R	61.1	66.0	75.6	110.2	201.9
WL	Blenheim Road (West)	L	69.1	70.3	72.4	79.0	113.4
WT		T	87.8	88.9	90.6	98.0	127.6
WR		R	93.7	106.0	184.5	584.8	1009.8
All Movements		All	73.9	75.8	80.9	102.8	149.3
Median Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Matipo Street (North)	L	46.0	50.0	50.0	53.0	94.0
NT		T	48.0	48.0	51.0	53.0	94.0
NR		R	58.0	65.0	79.0	107.0	246.0
EL	Blenheim Road (East)	L	85.0	86.0	87.0	88.0	90.0
ET		T	75.0	78.0	81.0	84.0	88.0
ER		R	78.0	80.0	84.0	88.0	95.0
SL	Matipo Street (South)	L	40.0	43.0	48.0	51.0	63.0
ST		T	42.0	45.0	47.0	49.0	63.0
SR		R	55.0	62.0	75.0	103.0	155.0
WL	Blenheim Road (West)	L	68.0	69.0	70.0	75.0	79.0
WT		T	81.0	84.0	87.0	93.0	97.0
WR		R	89.0	101.0	143.0	528.0	961.0
All Movements		All	71.0	73.0	76.0	82.0	91.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Matipo Street (North)	L	35.0	35.0	35.0	35.0	41.0
NT		T	32.0	32.0	32.0	32.0	41.0
NR		R	37.0	38.0	42.0	56.0	104.0
EL	Blenheim Road (East)	L	84.0	84.0	84.0	85.0	85.0
ET		T	69.0	69.0	70.0	70.0	70.0
ER		R	72.0	72.0	73.0	74.0	77.0
SL	Matipo Street (South)	L	29.0	29.0	29.0	30.0	31.0
ST		T	28.0	28.0	28.0	28.0	28.0
SR		R	35.0	36.0	40.0	53.0	78.0
WL	Blenheim Road (West)	L	67.0	67.0	67.0	68.0	69.0
WT		T	63.0	64.0	64.0	65.0	66.0
WR		R	67.0	69.0	83.0	109.0	134.0
All Movements		All	38.0	41.0	45.0	50.0	65.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Matipo Street (North)	L	86.0	87.3	86.0	86.0	215.0
NT		T	86.0	87.0	87.0	88.0	217.0
NR		R	93.0	103.0	111.0	191.0	446.3
EL	Blenheim Road (East)	L	89.0	91.0	94.0	100.0	106.0
ET		T	110.0	112.0	112.0	114.0	114.0
ER		R	107.0	108.0	109.0	113.0	118.0
SL	Matipo Street (South)	L	81.0	80.0	83.0	83.0	102.0
ST		T	81.0	82.0	82.0	84.0	101.0
SR		R	94.0	99.0	109.0	168.0	367.0
WL	Blenheim Road (West)	L	72.0	74.0	79.0	89.0	101.0
WT		T	120.0	120.0	123.0	128.0	133.0
WR		R	126.0	139.0	305.1	1120.0	1850.0
All Movements		All	102.0	105.0	109.0	118.0	159.0

Method 2 Existing Rule							
Mean Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Matipo Street (North)	L	58.1	59.0	56.9	56.9	95.9
NT		T	54.4	55.4	55.2	54.4	91.7
NR		R	65.2	68.4	71.2	76.6	157.4
EL	Blenheim Road (East)	L	87.5	87.3	87.5	87.1	86.4
ET		T	86.7	86.1	86.0	85.0	84.4
ER		R	86.6	86.2	87.4	88.3	90.3
SL	Matipo Street (South)	L	55.5	53.9	56.9	62.1	137.7
ST		T	50.9	51.0	50.0	51.5	103.6
SR		R	65.2	66.2	69.9	80.9	175.6
WL	Blenheim Road (West)	L	70.3	70.3	70.0	70.2	71.4
WT		T	89.8	88.9	89.5	88.9	90.3
WR		R	97.8	105.0	110.2	141.9	310.7
All Movements		All	75.7	76.0	77.4	82.1	138.7
Median Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Matipo Street (North)	L	50.0	52.0	47.0	48.0	72.0
NT		T	47.0	48.0	49.0	47.0	71.0
NR		R	60.0	65.0	68.0	76.0	126.0
EL	Blenheim Road (East)	L	86.0	86.0	86.0	86.0	85.0
ET		T	79.0	78.0	78.0	74.0	73.0
ER		R	81.0	80.0	81.0	82.0	85.0
SL	Matipo Street (South)	L	51.0	48.0	50.0	49.0	74.0
ST		T	46.0	45.0	43.0	44.0	68.0
SR		R	61.0	62.0	67.0	80.0	134.0
WL	Blenheim Road (West)	L	69.0	69.0	69.0	69.0	69.0
WT		T	85.0	84.0	84.0	83.0	85.0
WR		R	94.0	100.0	107.0	122.0	247.0
All Movements		All	72.0	73.0	74.0	76.0	93.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Matipo Street (North)	L	38.0	38.0	38.0	38.0	38.0
NT		T	32.0	32.0	32.0	32.0	32.0
NR		R	37.0	38.0	38.0	41.0	69.0
EL	Blenheim Road (East)	L	84.0	84.0	84.0	84.0	84.0
ET		T	69.0	69.0	69.0	69.0	69.0
ER		R	72.0	72.0	73.0	73.0	74.0
SL	Matipo Street (South)	L	32.0	32.0	32.0	32.0	32.0
ST		T	28.0	28.0	28.0	28.0	28.0
SR		R	35.6	36.0	38.0	43.0	70.0
WL	Blenheim Road (West)	L	67.0	67.0	67.0	67.0	67.0
WT		T	64.0	64.0	64.0	64.0	63.4
WR		R	68.0	69.0	71.0	78.0	97.0
All Movements		All	42.0	42.0	43.0	47.0	66.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Matipo Street (North)	L	87.0	89.0	86.0	87.0	181.4
NT		T	85.0	87.0	87.0	86.0	170.0
NR		R	99.0	102.6	104.0	108.0	281.0
EL	Blenheim Road (East)	L	91.0	90.0	91.0	90.0	89.0
ET		T	112.0	112.0	111.0	110.0	109.0
ER		R	107.0	107.0	109.4	110.0	112.0
SL	Matipo Street (South)	L	84.0	83.0	86.0	88.0	208.0
ST		T	81.0	82.0	80.0	83.0	183.0
SR		R	98.0	99.0	102.0	112.0	314.0
WL	Blenheim Road (West)	L	74.0	74.0	73.0	74.0	75.0
WT		T	122.0	120.0	122.0	121.0	123.0
WR		R	129.4	138.0	144.5	214.0	568.3
All Movements		All	104.0	105.0	107.0	112.0	227.0

Method 2 Changed Rule							
Mean Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Matipo Street (North)	L	55.8	57.0	54.5	54.9	96.3
NT		T	54.4	55.4	55.2	54.4	96.1
NR		R	65.4	68.5	71.8	77.5	165.2
EL	Blenheim Road (East)	L	87.5	87.4	87.4	87.1	86.4
ET		T	86.8	86.2	86.0	85.0	84.7
ER		R	86.2	86.4	87.3	88.1	90.9
SL	Matipo Street (South)	L	52.1	50.5	51.8	50.8	74.0
ST		T	50.9	50.9	49.9	50.0	73.8
SR		R	64.9	66.0	69.5	79.7	146.4
WL	Blenheim Road (West)	L	70.4	70.3	69.8	70.1	71.5
WT		T	89.9	88.9	89.4	89.1	89.8
WR		R	97.9	106.0	111.5	144.8	320.4
All Movements		All	75.3	75.8	77.0	81.6	133.3
Median Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Matipo Street (North)	L	48.0	50.0	44.0	46.0	72.0
NT		T	47.0	48.0	49.0	47.0	75.0
NR		R	60.0	65.0	69.0	77.0	133.0
EL	Blenheim Road (East)	L	86.0	86.0	86.0	86.0	85.0
ET		T	79.0	78.0	77.0	75.0	74.0
ER		R	80.0	80.0	81.0	82.0	85.0
SL	Matipo Street (South)	L	46.0	43.0	45.0	43.0	54.0
ST		T	46.0	45.0	42.0	42.0	57.0
SR		R	61.0	62.0	67.0	79.0	115.0
WL	Blenheim Road (West)	L	69.0	69.0	69.0	69.0	69.0
WT		T	85.0	84.0	84.0	84.0	84.0
WR		R	94.0	101.0	107.0	125.0	272.0
All Movements		All	72.0	73.0	74.0	76.0	92.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Matipo Street (North)	L	35.0	35.0	35.0	35.0	35.0
NT		T	32.0	32.0	32.0	32.0	32.0
NR		R	37.0	38.0	38.0	42.0	73.0
EL	Blenheim Road (East)	L	84.0	84.0	84.0	84.0	84.0
ET		T	69.0	69.0	69.0	69.0	69.0
ER		R	72.0	72.0	72.6	73.0	74.0
SL	Matipo Street (South)	L	29.0	29.0	29.0	29.0	29.0
ST		T	28.0	28.0	28.0	28.0	28.0
SR		R	35.0	36.0	38.0	42.0	66.0
WL	Blenheim Road (West)	L	67.0	67.0	67.0	67.0	67.0
WT		T	64.0	64.0	64.0	64.0	64.0
WR		R	68.0	69.0	71.0	79.0	97.0
All Movements		All	40.0	41.0	42.0	46.0	65.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Matipo Street (North)	L	86.0	87.3	84.0	86.0	181.5
NT		T	85.0	87.0	87.0	86.0	179.0
NR		R	99.0	103.0	104.8	109.0	288.0
EL	Blenheim Road (East)	L	91.0	91.0	91.0	90.0	89.0
ET		T	112.0	112.0	111.0	111.0	110.0
ER		R	107.0	108.0	110.0	110.0	113.0
SL	Matipo Street (South)	L	82.0	80.0	82.0	81.0	146.8
ST		T	81.0	82.0	80.0	82.0	130.0
SR		R	97.5	99.0	101.0	111.0	265.0
WL	Blenheim Road (West)	L	74.0	74.0	73.0	74.0	75.0
WT		T	122.0	120.0	122.0	121.0	122.0
WR		R	129.4	139.0	145.0	218.7	585.0
All Movements		All	104.0	105.0	107.0	111.0	215.0

A9.7 Full Queue Length Analysis Results

Method 1							
Existing Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Matipo Street (North)	L	1.3	1.5	1.6	1.7	4.0
N2		T	2.1	2.6	3.2	3.8	5.1
N3		R	1.4	1.7	2.2	3.5	6.9
EL1	Blenheim Road (East)	L	1.0	1.1	1.2	1.4	1.6
E1		T	2.9	3.7	4.3	4.9	5.5
E2		T	2.2	2.9	3.7	4.5	5.2
E3		R	1.2	1.4	1.6	1.8	2.1
S1	Matipo Street (South)	L	1.5	1.8	2.3	3.9	14.0
S2		T	1.8	2.2	2.8	4.4	8.5
S3		R	1.4	1.7	2.2	3.9	10.2
WL1	Blenheim Road (West)	L	1.0	1.1	1.1	1.2	1.3
W1		T	2.3	3.0	3.8	4.5	5.2
W2		T	1.9	2.4	3.0	9.7	28.2
W3		R	1.4	1.9	3.5	8.4	10.1
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Matipo Street (North)	L	1.6	2.0	2.3	2.7	9.0
N2		T	3.3	4.5	5.9	7.1	9.1
N3		R	2.1	2.8	3.8	5.8	9.7
EL1	Blenheim Road (East)	L	1.1	1.3	1.6	2.0	2.4
E1		T	4.8	6.0	7.1	8.1	9.2
E2		T	3.4	5.0	6.3	7.7	9.3
E3		R	1.5	1.9	2.3	2.8	3.4
S1	Matipo Street (South)	L	2.0	2.8	3.8	6.9	27.3
S2		T	2.8	3.6	4.9	7.4	13.0
S3		R	2.0	2.6	3.6	6.1	13.1
WL1	Blenheim Road (West)	L	1.1	1.2	1.3	1.5	1.9
W1		T	4.9	6.3	7.7	9.7	11.0
W2		T	3.6	4.9	6.2	15.0	35.7
W3		R	2.2	3.1	5.3	10.0	11.7
Changed Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Matipo Street (North)	L	1.3	1.5	1.6	1.8	7.8
N2		T	2.1	2.6	3.2	3.8	5.5
N3		R	1.4	1.7	2.3	3.7	10.6
EL1	Blenheim Road (East)	L	1.0	1.1	1.2	1.3	1.6
E1		T	2.9	3.7	4.2	4.9	5.6
E2		T	2.2	2.9	3.7	4.6	5.2
E3		R	1.2	1.4	1.6	1.7	2.1
S1	Matipo Street (South)	L	1.5	1.8	2.1	2.5	4.1
S2		T	1.8	2.2	2.7	3.3	4.1
S3		R	1.4	1.7	2.1	3.7	9.3
WL1	Blenheim Road (West)	L	1.0	1.1	1.1	1.2	1.3
W1		T	2.3	3.1	3.8	4.5	5.2
W2		T	1.9	2.4	2.9	9.7	27.3
W3		R	1.4	1.9	3.3	8.4	10.0
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Matipo Street (North)	L	1.7	2.0	2.3	2.7	19.2
N2		T	3.3	4.5	5.9	7.1	9.7
N3		R	2.1	2.8	3.9	6.0	13.6
EL1	Blenheim Road (East)	L	1.1	1.3	1.6	1.9	2.5
E1		T	4.8	6.0	6.9	8.0	9.3
E2		T	3.4	4.9	6.3	7.7	9.1
E3		R	1.5	1.9	2.3	2.9	3.4
S1	Matipo Street (South)	L	2.1	2.8	3.4	4.1	8.5
S2		T	2.8	3.6	4.7	6.0	7.8
S3		R	2.0	2.6	3.5	5.8	12.5
WL1	Blenheim Road (West)	L	1.1	1.2	1.3	1.6	1.8
W1		T	5.0	6.4	7.7	9.6	11.1
W2		T	3.6	4.8	6.1	15.0	34.7
W3		R	2.2	3.1	5.2	10.1	11.6

Method 2							
Existing Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Matipo Street (North)	L	1.5	1.5	1.4	1.3	7.1
N2		T	2.7	2.6	2.4	2.1	1.9
N3		R	1.3	1.7	2.4	3.2	9.5
EL1	Blenheim Road (East)	L	1.1	1.1	1.1	1.1	1.0
E1		T	3.9	3.7	3.3	3.0	2.4
E2		T	3.3	2.9	2.7	2.2	1.7
E3		R	1.1	1.4	1.7	2.2	2.8
S1	Matipo Street (South)	L	1.9	1.8	1.8	1.9	4.9
S2		T	2.4	2.2	2.1	2.1	2.5
S3		R	1.2	1.7	2.3	3.0	7.4
WL1	Blenheim Road (West)	L	1.0	1.1	1.0	1.0	1.0
W1		T	3.4	3.0	2.9	2.6	2.1
W2		T	2.7	2.4	2.2	2.0	7.5
W3		R	1.3	1.9	2.4	3.9	7.7
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Matipo Street (North)	L	2.1	2.0	1.8	1.7	12.3
N2		T	4.8	4.5	4.0	3.4	2.6
N3		R	1.6	2.8	4.1	5.8	14.0
EL1	Blenheim Road (East)	L	1.4	1.3	1.3	1.2	1.1
E1		T	6.5	6.0	5.6	5.1	3.9
E2		T	5.5	5.0	4.4	3.6	2.5
E3		R	1.3	1.9	2.6	3.5	5.3
S1	Matipo Street (South)	L	3.1	2.8	2.7	2.7	7.4
S2		T	4.1	3.6	3.2	3.1	3.3
S3		R	1.6	2.6	4.0	5.5	11.9
WL1	Blenheim Road (West)	L	1.1	1.2	1.1	1.1	1.1
W1		T	7.1	6.3	6.1	5.4	4.3
W2		T	5.5	4.9	4.2	3.9	10.9
W3		R	1.7	3.1	4.4	6.8	10.9
Changed Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Matipo Street (North)	L	1.6	1.5	1.4	1.3	8.4
N2		T	2.7	2.6	2.4	2.1	1.9
N3		R	1.3	1.7	2.4	3.2	9.9
EL1	Blenheim Road (East)	L	1.1	1.1	1.1	1.1	1.0
E1		T	3.9	3.7	3.3	3.0	2.3
E2		T	3.3	2.9	2.7	2.2	1.8
E3		R	1.1	1.4	1.7	2.2	2.9
S1	Matipo Street (South)	L	2.0	1.8	1.7	1.7	1.4
S2		T	2.4	2.2	2.1	1.9	1.6
S3		R	1.2	1.7	2.2	2.9	6.2
WL1	Blenheim Road (West)	L	1.0	1.1	1.0	1.0	1.0
W1		T	3.4	3.1	2.9	2.6	2.0
W2		T	2.7	2.4	2.2	2.0	8.2
W3		R	1.3	1.9	2.4	3.9	7.7
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Matipo Street (North)	L	2.2	2.0	1.8	1.7	14.3
N2		T	4.8	4.5	3.9	3.4	2.7
N3		R	1.6	2.8	4.1	5.9	14.3
EL1	Blenheim Road (East)	L	1.3	1.3	1.3	1.2	1.1
E1		T	6.5	6.0	5.5	5.1	3.9
E2		T	5.5	4.9	4.4	3.5	2.6
E3		R	1.3	1.9	2.5	3.5	5.3
S1	Matipo Street (South)	L	3.1	2.8	2.6	2.3	2.0
S2		T	4.1	3.6	3.2	2.9	2.3
S3		R	1.6	2.6	3.9	5.4	10.6
WL1	Blenheim Road (West)	L	1.2	1.2	1.1	1.1	1.1
W1		T	7.1	6.4	6.0	5.4	4.1
W2		T	5.5	4.8	4.2	3.9	11.9
W3		R	1.8	3.1	4.5	6.9	11.0

APPENDIX A10

Intersection 8 –Matipo Street/Riccarton Road

Full Data

Table of Contents

A10.1 Approach Photos

Figure A10.1.1 - Matipo Street South Approach

Figure A10.1.2 - Riccarton Road West Approach

Figure A10.1.3 - Riccarton Road East Approach

A10.2 Surveyed Traffic Volume Data

Intersection 8: Matipo Street/Riccarton Road

Survey Date Wednesday, 27 September 2006

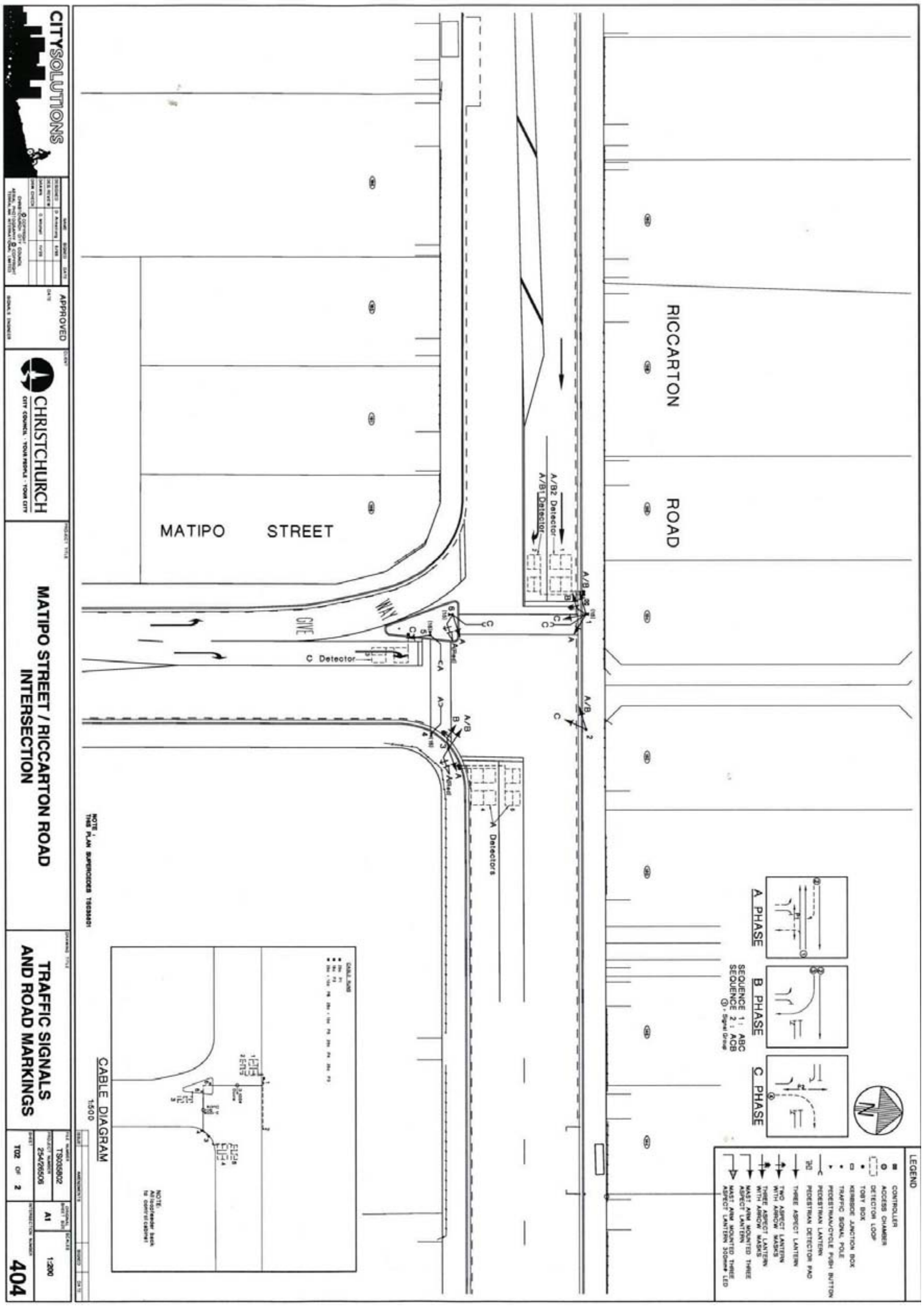
Light Vehicles			Matipo		Riccarton (East)		Riccarton (West)		TOTAL
			L	R	T	L	T	R	
3:15	-	3:30	60	23	70	22	77	46	298
3:30	-	3:45	86	45	99	33	149	75	487
3:45	-	4:00	83	52	117	25	161	82	520
4:00	-	4:15	104	24	128	43	110	89	498
4:15	-	4:30	84	24	87	21	116	86	418
4:30	-	4:45	79	21	98	17	110	82	407

Heavy Vehicles			Matipo		Riccarton (East)		Riccarton (West)		TOTAL
			L	R	T	L	T	R	
3:15	-	3:30	0	0	7	0	5	1	13
3:30	-	3:45	0	3	8	3	14	0	28
3:45	-	4:00	1	2	9	1	10	0	23
4:00	-	4:15	3	1	7	1	5	0	17
4:15	-	4:30	1	1	7	3	6	1	19
4:30	-	4:45	0	1	8	2	3	0	14

Total	Matipo		Riccarton (East)		Riccarton (West)	
(3:15pm - 4:45pm)	L	R	T	L	T	R
Light	496	189	599	161	723	460
Heavy	5	8	46	10	43	2

Peak Hour	Matipo		Riccarton (East)		Riccarton (West)	
(3:30pm - 4:30pm)	L	R	T	L	T	R
Light	357	145	431	122	536	332
Heavy	5	7	31	8	35	1

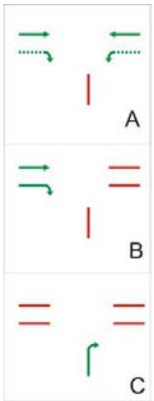
A10.3 Traffic Signal Plan



A10.4 Observed and Modelled Signal Timings

Table A4.7 - Intersection 8 Matipo Street/Riccarton Road (SCATS ID = 404)

Traffic Count Day		Wednesday 27 September, 2006		
Observed Signal Day		Tuesday 10 October, 2006		
Observed Time Period		3:15pm to 4:45pm		
Observed Phase Timings				
Phase	Count	Minimum (s)	Maximum (s)	Average (s)
A	64	37	92	59
B	25	10	20	15
C	54	11	15	20
Cycle	-	-	-	94
Modelled Phase Timings				
A	-	-	-	45
B	-	-	-	25
C	-	-	-	20
Cycle	-	-	-	90



A10.5 Results Summary

A10.5.1 Journey Times Method 1

Figure A10.5.1 to Figure A10.5.3 present journey time comparisons for the right and left turn movements off Riccarton Road and for the average journey time for all movements through the intersection.

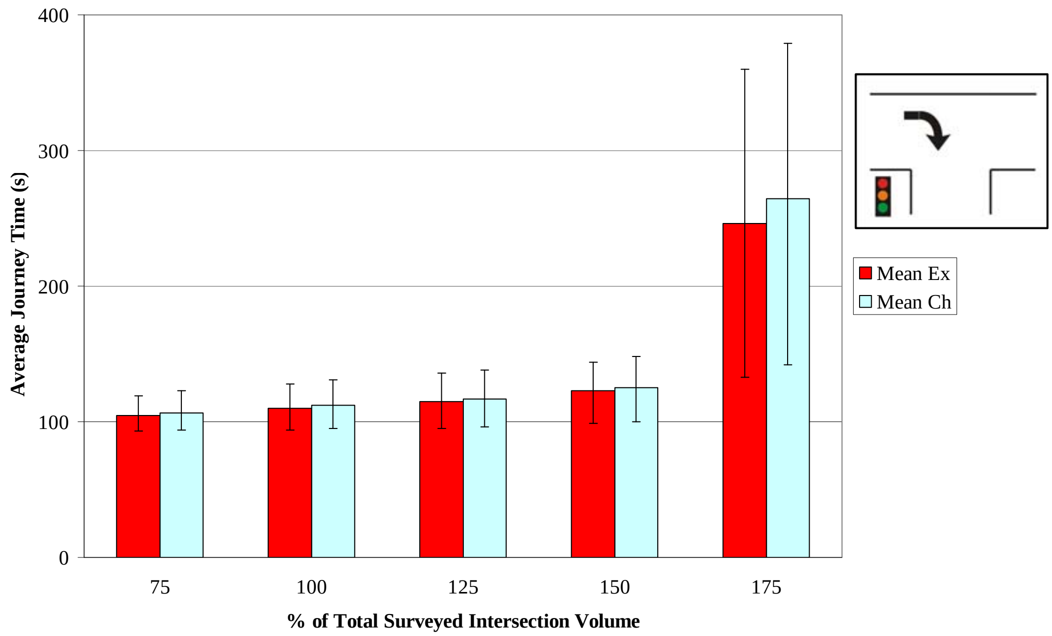


Figure A10.5.1 - Intersection 8, M1, Riccarton Road (West) Right Turn Journey Time Comparison

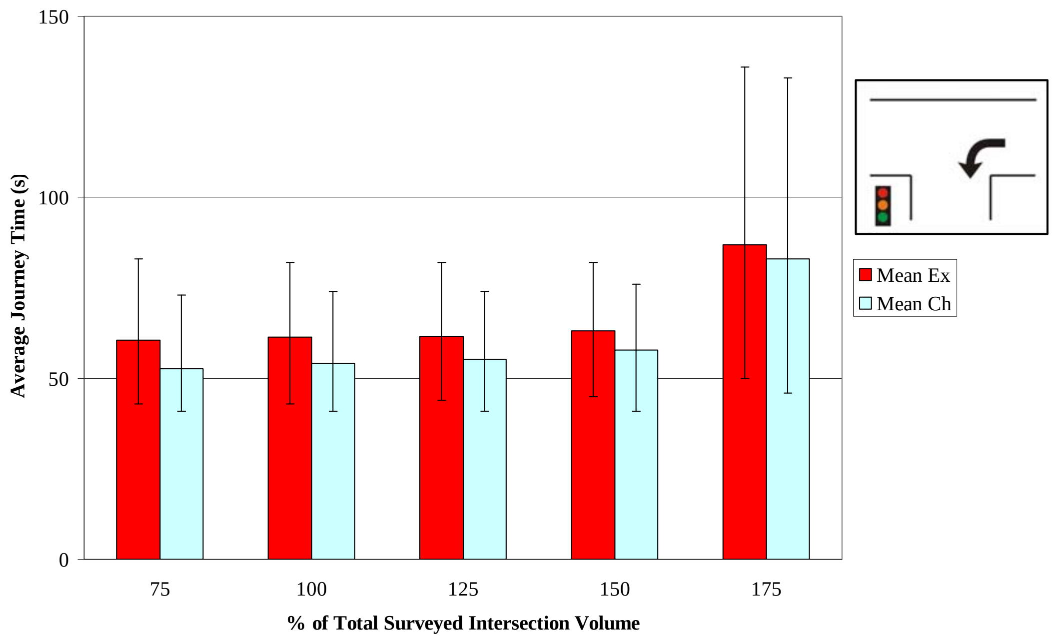


Figure A10.5.2 - Intersection 8, M1, Riccarton Road (East) Left Turn Journey Time Comparison

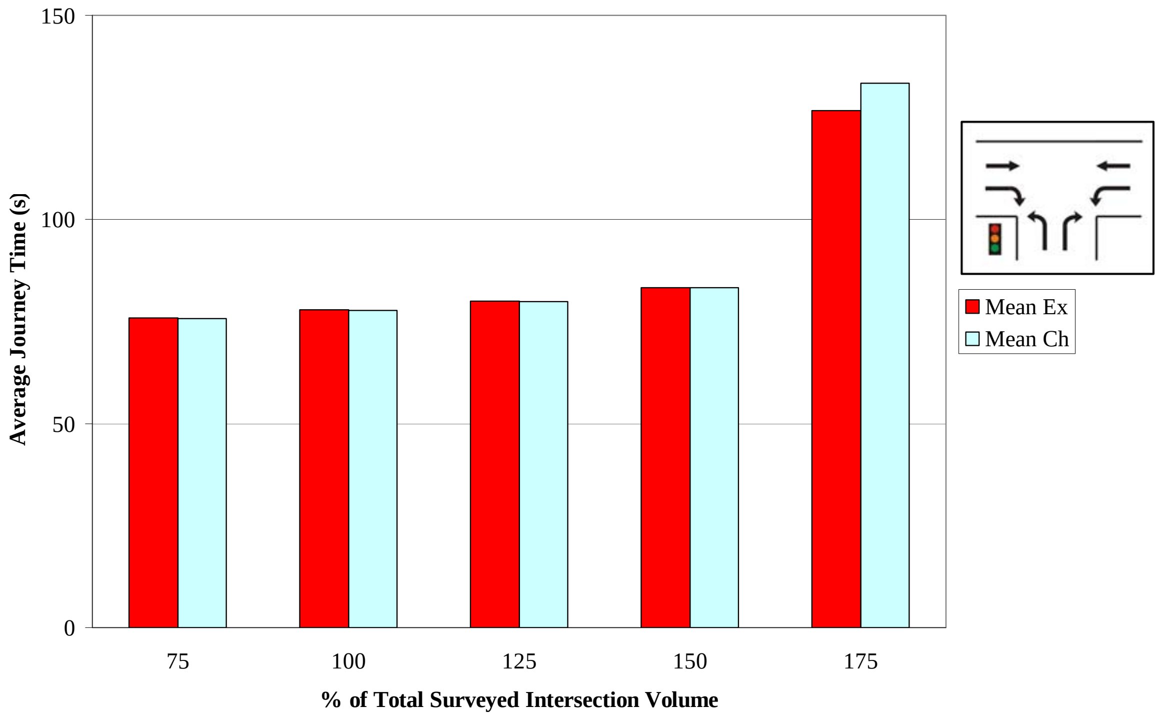


Figure A10.5.3 - Intersection 8, M1, Total Intersection Journey Time Comparison

A10.5.2 Journey Times Method 2

Figure A10.5.4 to Figure A10.5.7 present journey time comparisons for the right and left turn movements off Riccarton Road and for the overall journey time for all movements through the intersection.

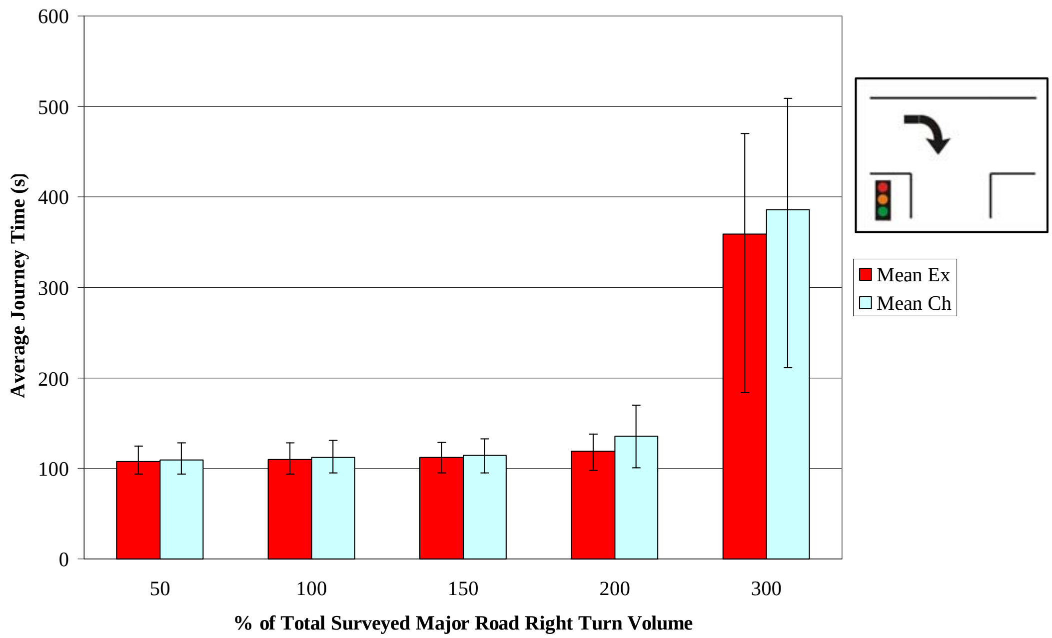


Figure A10.5.4 - Intersection 8, M2, Riccarton Road (West) Right Turn Journey Time Comparison

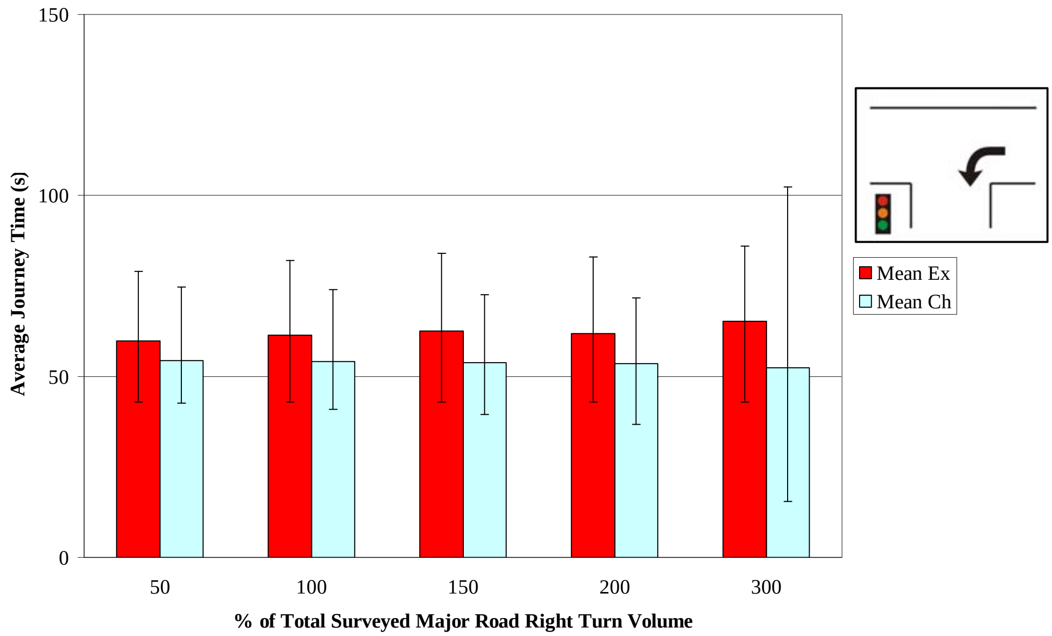


Figure A10.5.5 - Intersection 8, M2, Riccarton Road (East) Left Turn Journey Time Comparison

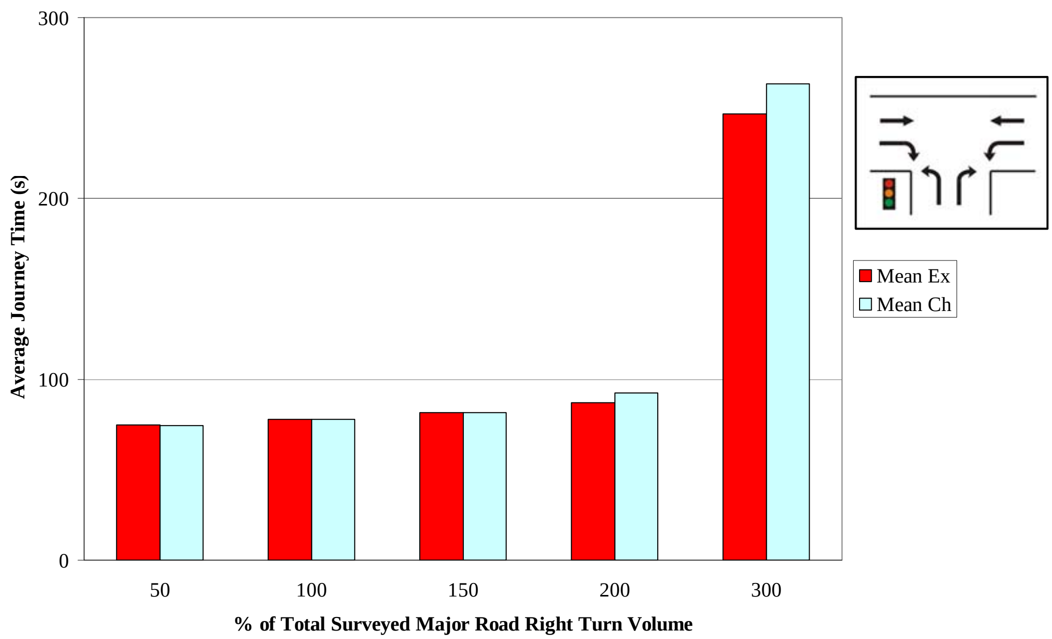


Figure A10.5.6 - Intersection 8, M2, Total Intersection Journey Time Comparison

Table A10.5.1 summarises the average journey times for all movements for each volume scenario.

Table A10.5.1 - Intersection 8, M2, Average Journey Time Comparison

Approach	Mvt	Average Journey Time (seconds/vehicle) for Various % Scenarios									
		50%		100%		150%		200%		300%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Riccarton Road (East)	L	60	54	61	54	63	54	62	54	65	52
	T	71	71	71	71	71	71	70	70	70	69
Matipo Street (South)	L	44	44	42	42	41	41	40	40	39	39
	R	56	56	57	57	57	57	55	55	54	55
Riccarton Road (West)	T	97	97	97	97	97	97	97	99	284	305
	R	108	110	110	112	112	115	119	136	359	386
Total	All	75	74	78	78	82	82	87	92	247	263

It is evident from the analysis that with the changed rule, as expected, that the right turn journey increases and the left turn journey time decreases. Overall the existing rule proves more efficient. Table A10.5.2 presents a summary of the increase or decrease for these two movements as a result of the rule change to nearside priority.

Table A10.5.2 - Intersection 8, M1, Right and Left Turn Journey Time Changes

Movement	Change in Journey Time (seconds/vehicle) for Various % Scenarios				
	75%	100%	125%	150%	175%
Riccarton Road Right Turn	2	2	2	16	27
Riccarton Road Left Turn	-5	-7	-9	-8	-13

Table A10.5.2 shows that the increase in right turn journey time as a result of the rule change to nearside priority is smaller than the decrease in left turn journey time for the first three volume scenarios. For the last two scenarios the increase in right turn journey time is approximately double the decrease for the left turn journey time.

Overall there are small differences in the average journey time for all movements through the intersection for the first three scenarios. The difference becomes greater in the last two scenarios with the existing rule giving a faster average journey time.

A10.5.3 Queue Lengths Method 1

Figure A10.5.7 to Figure A10.5.10 present queue length comparisons for right and left turns off Riccarton Road and also for the longest queue in any lane on the Matipo Street approach.

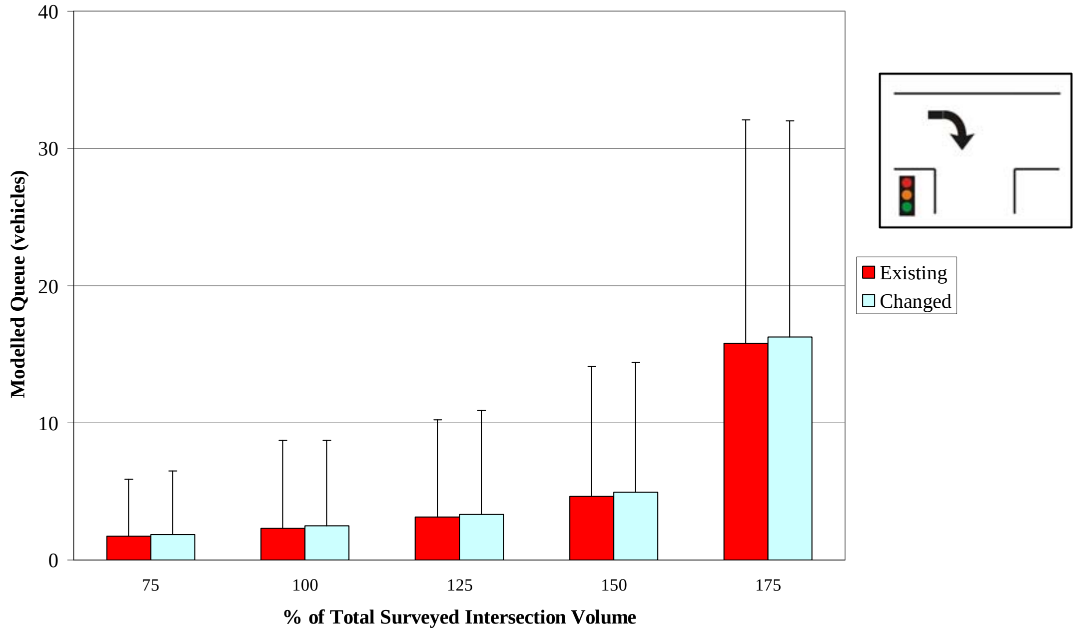


Figure A10.5.7 - Intersection 8, M1, Riccarton Road (West) Right Turn Queue Comparison

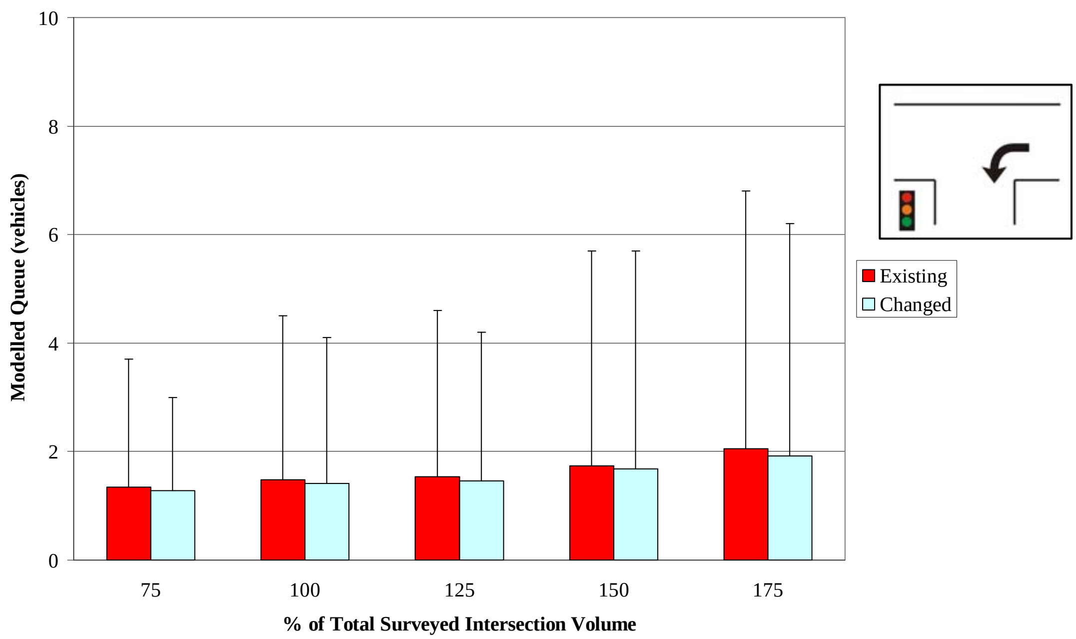


Figure A10.5.8 - Intersection 8, M1, Riccarton Road (East) Left Turn Queue Comparison

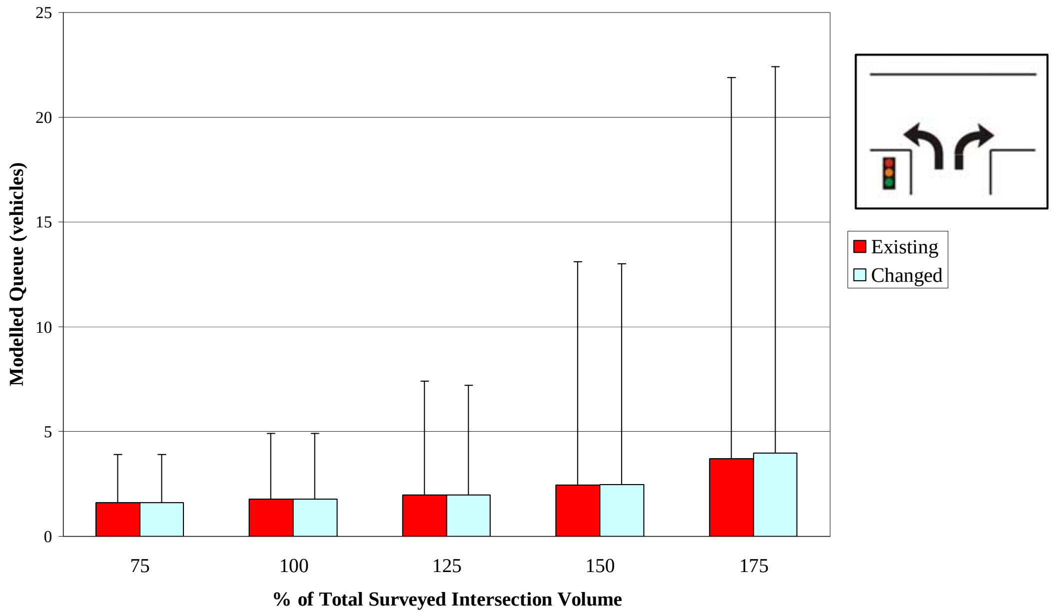


Figure A10.5.9 - Intersection 8, M1, Matipo Street (South) Queue Comparison

A10.5.4 Queue Lengths Method 2

Figure A10.5.10 to Figure A10.5.12 present queue length comparisons for right and left turns off Riccarton Road and also for the longest queue in any lane on the Matipo Street approach.

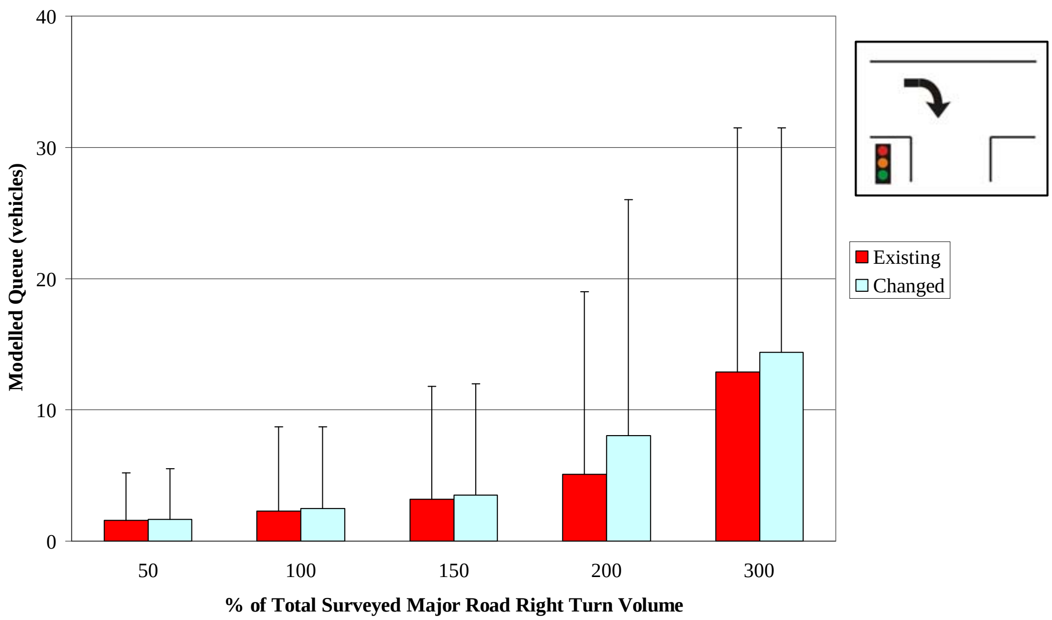


Figure A10.5.10 - Intersection 8, M2, Riccarton Road (West) Right Turn Queue Comparison

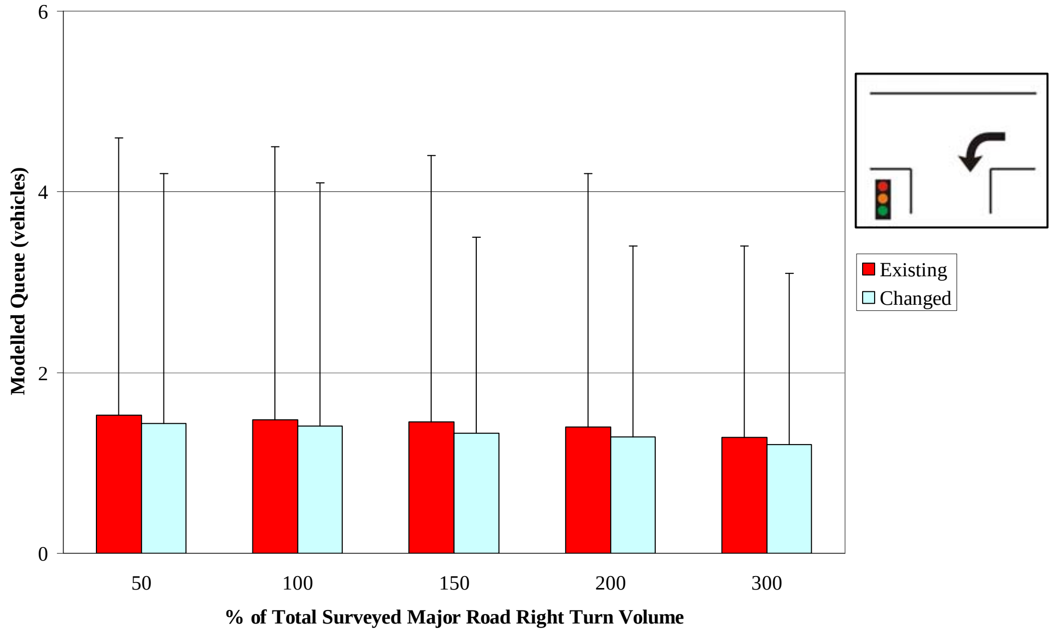


Figure A10.5.11 - Intersection 8, M2, Riccarton Road (East) Left Turn Queue Comparison

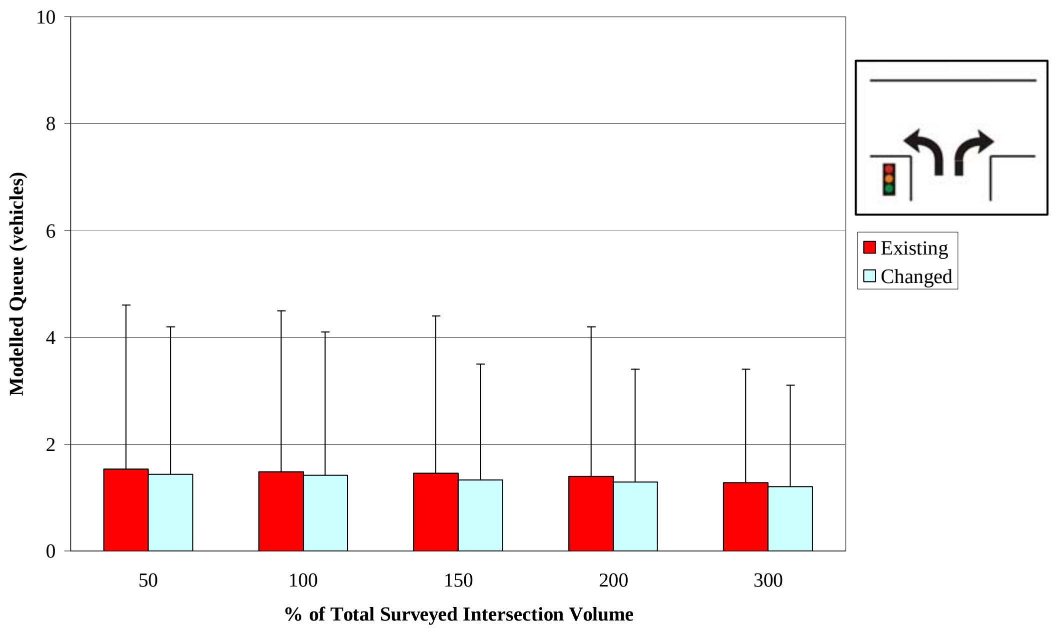


Figure A10.5.12 - Intersection 8, M2, Matipo Street (South) Queue Comparison

Table A10.5.3 summarises the average queue lengths for all movements for each volume scenario.

Table A10.5.3 - Intersection 8, M2, Average Queue Comparison

Approach	Mvt	Average Queue Length (vehicles) for Various % Scenarios									
		50%		100%		150%		200%		300%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Riccarton Road (East)	L	1.5	1.4	1.5	1.4	1.5	1.3	1.4	1.3	1.3	1.2
	T	3.3	3.3	3.0	3.0	2.9	2.9	2.5	2.5	2.1	2.1
Matipo Street (South)	L	1.8	1.8	1.8	1.8	1.7	1.7	1.6	1.6	1.4	1.4
	R	1.5	1.5	1.3	1.3	1.4	1.4	1.2	1.2	1.1	1.2
Riccarton Road (West)	T	2.0	2.0	1.9	1.9	1.8	1.8	1.7	1.7	3.4	4.1
	R	1.6	1.7	2.3	2.5	3.2	3.5	5.1	8.1	12.9	14.4

It is evident from the analysis that with the changed rule the right turn queue length increases very slightly as the proportion of right turning vehicles increases. Similarly the left turn queue length decreases very slightly.

Overall there is very little difference in the queue lengths at the intersection. This indicates that at the surveyed total intersection volume, the proportion of right turning vehicles has little impact on the overall performance of the intersection under either rule.

A10.6 Full Journey Time Analysis Results

Method 1 Existing Rule							
Mean Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
EL	Riccarton Road (East)	L	61.7	63.4	74.9	121.3	195.5
ET		T	70.1	72.3	84.4	130.4	203.2
SL	Matipo Street (South)	L	39.9	42.4	46.3	52.4	58.6
SR		R	55.4	56.6	57.2	58.1	60.7
WT	Riccarton Road (West)	T	96.2	97.1	97.7	98.4	108.6
WR		R	104.8	110.2	114.9	121.3	153.4
All Movements		All	76.0	78.3	83.6	99.8	131.1
Median Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
EL	Riccarton Road (East)	L	56.0	58.0	62.0	82.0	148.0
ET		T	65.0	68.0	75.0	94.0	157.0
SL	Matipo Street (South)	L	37.0	37.0	42.0	48.0	52.0
SR		R	54.0	56.0	57.0	58.0	60.0
WT	Riccarton Road (West)	T	94.0	94.0	95.0	95.0	97.0
WR		R	100.0	108.0	113.0	120.0	136.0
All Movements		All	89.0	90.0	91.0	94.0	99.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
EL	Riccarton Road (East)	L	43.0	44.0	45.0	51.0	63.0
ET		T	54.0	54.0	55.0	59.0	76.0
SL	Matipo Street (South)	L	37.0	37.0	37.0	37.0	37.0
SR		R	25.0	27.0	27.0	30.0	32.0
WT	Riccarton Road (West)	T	92.0	92.0	92.0	92.0	93.0
WR		R	93.0	94.0	95.0	97.0	100.0
All Movements		All	40.0	43.0	46.0	52.0	56.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
EL	Riccarton Road (East)	L	83.0	84.0	95.0	187.0	278.5
ET		T	92.0	93.0	100.0	196.0	273.0
SL	Matipo Street (South)	L	44.0	51.0	60.0	71.0	82.0
SR		R	84.0	85.0	86.0	86.0	89.0
WT	Riccarton Road (West)	T	104.0	106.0	107.0	108.0	116.0
WR		R	119.0	128.0	136.0	145.0	208.0
All Movements		All	100.0	104.0	110.0	136.0	186.0

Method 1 Changed Rule							
Mean Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
EL	Riccarton Road (East)	L	53.3	55.0	56.3	59.0	86.5
ET		T	69.8	71.0	72.9	75.0	101.8
SL	Matipo Street (South)	L	39.9	42.4	46.2	52.8	66.6
SR		R	55.4	56.6	57.0	58.7	60.8
WT	Riccarton Road (West)	T	96.3	97.1	97.7	98.3	160.2
WR		R	106.7	112.5	117.1	125.8	269.3
All Movements		All	75.8	77.9	80.1	83.7	135.7
Median Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
EL	Riccarton Road (East)	L	47.0	50.0	54.0	57.0	74.0
ET		T	65.0	67.0	71.0	74.0	92.0
SL	Matipo Street (South)	L	37.0	37.0	42.0	49.0	63.0
SR		R	54.0	56.0	57.0	59.0	60.0
WT	Riccarton Road (West)	T	94.0	94.0	95.0	95.0	147.0
WR		R	102.0	110.0	116.0	125.0	281.0
All Movements		All	88.0	89.0	90.0	91.0	100.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
EL	Riccarton Road (East)	L	41.0	41.0	41.0	42.0	48.0
ET		T	54.0	54.0	55.0	55.0	61.0
SL	Matipo Street (South)	L	37.0	37.0	37.0	37.0	39.0
SR		R	25.0	27.0	27.0	30.0	32.0
WT	Riccarton Road (West)	T	92.0	92.0	92.0	92.0	95.0
WR		R	94.0	95.0	96.0	100.0	142.0
All Movements		All	40.0	41.0	44.0	51.0	57.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
EL	Riccarton Road (East)	L	73.0	74.0	74.0	76.0	137.0
ET		T	92.0	92.0	94.0	95.0	151.0
SL	Matipo Street (South)	L	44.0	51.0	59.0	70.0	91.0
SR		R	84.0	85.0	86.0	87.0	89.0
WT	Riccarton Road (West)	T	104.0	106.0	107.0	108.0	238.0
WR		R	123.0	132.0	139.0	149.0	386.0
All Movements		All	101.0	104.0	107.0	111.0	233.0

Method 2 Existing Rule							
Mean Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
EL	Riccarton Road (East)	L	60.8	63.4	70.7	70.6	131.2
ET		T	71.8	72.3	77.7	77.1	136.2
SL	Matipo Street (South)	L	44.0	42.4	41.3	40.4	39.0
SR		R	56.5	56.6	56.9	54.8	54.8
WT	Riccarton Road (West)	T	96.9	97.1	97.0	97.0	272.1
WR		R	107.6	110.2	112.2	119.0	344.7
All Movements		All	74.8	78.3	83.4	88.7	249.6
Median Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
EL	Riccarton Road (East)	L	57.0	58.0	60.0	60.0	63.0
ET		T	69.0	68.0	69.0	67.0	68.0
SL	Matipo Street (South)	L	39.0	37.0	37.0	37.0	37.0
SR		R	55.0	56.0	57.0	53.0	54.0
WT	Riccarton Road (West)	T	94.0	94.0	94.0	94.0	314.0
WR		R	103.0	108.0	111.0	117.0	386.0
All Movements		All	81.0	90.0	92.0	94.0	240.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
EL	Riccarton Road (East)	L	44.0	44.0	44.0	44.0	45.0
ET		T	54.0	54.0	54.0	54.0	54.0
SL	Matipo Street (South)	L	37.0	37.0	37.0	37.0	37.0
SR		R	27.0	27.0	27.0	26.0	25.0
WT	Riccarton Road (West)	T	92.0	92.0	92.0	92.0	102.0
WR		R	94.0	94.0	95.0	98.0	154.0
All Movements		All	42.0	43.0	43.0	44.0	54.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
EL	Riccarton Road (East)	L	80.0	84.0	87.0	87.0	108.3
ET		T	93.0	93.0	96.0	95.0	100.0
SL	Matipo Street (South)	L	55.0	51.0	48.0	46.0	42.0
SR		R	86.0	85.0	86.0	84.0	84.0
WT	Riccarton Road (West)	T	106.0	106.0	106.0	106.0	383.0
WR		R	125.0	128.0	129.0	138.0	470.0
All Movements		All	99.0	104.0	112.0	121.8	449.0

Method 2 Changed Rule							
Mean Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
EL	Riccarton Road (East)	L	55.2	55.0	54.5	54.2	53.1
ET		T	71.5	71.0	71.0	70.1	68.7
SL	Matipo Street (South)	L	44.0	42.4	41.3	40.4	39.1
SR		R	56.5	56.6	56.9	54.8	55.9
WT	Riccarton Road (West)	T	96.9	97.1	97.0	97.9	307.0
WR		R	109.8	112.5	114.8	134.2	388.1
All Movements		All	74.6	77.9	81.7	91.8	264.7
Median Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
EL	Riccarton Road (East)	L	52.0	50.0	50.0	49.0	47.0
ET		T	69.0	67.0	67.0	65.0	62.0
SL	Matipo Street (South)	L	40.0	37.0	37.0	37.0	37.0
SR		R	55.0	56.0	57.0	53.0	55.0
WT	Riccarton Road (West)	T	94.0	94.0	94.0	95.0	352.0
WR		R	105.0	110.0	114.0	127.0	441.0
All Movements		All	80.0	89.0	92.0	93.0	296.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
EL	Riccarton Road (East)	L	41.0	41.0	41.0	41.0	41.0
ET		T	54.0	54.0	54.0	54.0	54.0
SL	Matipo Street (South)	L	37.0	37.0	37.0	37.0	37.0
SR		R	27.0	27.0	27.0	26.0	25.0
WT	Riccarton Road (West)	T	92.0	92.0	92.0	92.0	123.0
WR		R	94.0	95.0	96.0	101.0	217.0
All Movements		All	41.0	41.0	42.0	43.0	54.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
EL	Riccarton Road (East)	L	73.0	74.0	73.0	74.7	72.3
ET		T	92.0	92.0	93.0	92.0	90.0
SL	Matipo Street (South)	L	55.0	51.0	48.0	46.0	43.0
SR		R	86.0	85.0	86.0	84.0	86.0
WT	Riccarton Road (West)	T	106.0	106.0	106.0	107.0	414.0
WR		R	129.0	132.0	133.0	166.0	511.0
All Movements		All	99.0	104.0	112.0	131.0	481.0

A10.7 Full Queue Length Analysis Results

Method 1							
Existing Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
E1	Riccarton Road (East)	L	1.3	1.5	1.7	2.3	2.3
E2		T	2.4	3.4	6.4	14.6	33.0
S1	Matipo Street (South)	L	1.6	1.8	2.0	2.5	3.3
S2		R	1.3	1.3	1.5	1.7	1.9
W1	Riccarton Road (West)	T	1.6	1.9	2.2	2.4	2.7
W2		R	1.7	2.3	3.2	4.6	9.3
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
E1	Riccarton Road (East)	L	3.8	4.9	5.1	5.9	5.5
E2		T	9.6	15.7	30.4	59.6	75.8
S1	Matipo Street (South)	L	3.9	4.9	7.7	14.5	18.9
S2		R	2.4	3.0	3.9	5.3	6.4
W1	Riccarton Road (West)	T	5.6	6.3	6.4	7.9	10.2
W2		R	6.0	8.6	10.6	14.0	28.0
Changed Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
E1	Riccarton Road (East)	L	1.3	1.4	1.4	1.6	1.9
E2		T	2.4	3.0	3.9	4.8	9.5
S1	Matipo Street (South)	L	1.6	1.8	2.0	2.5	3.9
S2		R	1.3	1.3	1.5	1.8	1.9
W1	Riccarton Road (West)	T	1.6	1.9	2.2	2.4	2.7
W2		R	1.9	2.5	3.3	5.0	16.4
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
E1	Riccarton Road (East)	L	3.1	4.2	4.2	5.5	6.2
E2		T	9.6	12.1	15.5	18.4	37.9
S1	Matipo Street (South)	L	3.9	5.1	7.6	13.3	18.8
S2		R	2.4	3.0	3.8	5.1	6.2
W1	Riccarton Road (West)	T	5.6	6.3	6.3	8.0	13.1
W2		R	6.7	8.7	10.8	15.3	32.2

Method 2							
Existing Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
E1	Riccarton Road (East)	L	1.5	1.5	1.5	1.4	1.3
E2		T	3.3	3.4	3.6	3.6	9.2
S1	Matipo Street (South)	L	1.8	1.8	1.7	1.6	1.5
S2		R	1.5	1.3	1.4	1.2	1.0
W1	Riccarton Road (West)	T	2.0	1.9	1.8	1.7	3.0
W2		R	1.6	2.3	3.2	5.1	12.4
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
E1	Riccarton Road (East)	L	4.7	4.9	4.3	3.9	3.5
E2		T	13.0	15.7	17.1	19.3	24.2
S1	Matipo Street (South)	L	5.8	4.9	5.1	4.0	3.6
S2		R	3.7	3.0	3.0	2.3	1.2
W1	Riccarton Road (West)	T	6.6	6.3	5.8	4.8	24.1
W2		R	5.4	8.6	12.0	18.7	31.7
Changed Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
E1	Riccarton Road (East)	L	1.4	1.4	1.3	1.3	1.2
E2		T	3.3	3.0	2.9	2.4	2.0
S1	Matipo Street (South)	L	1.8	1.8	1.7	1.6	1.4
S2		R	1.5	1.3	1.4	1.2	1.1
W1	Riccarton Road (West)	T	2.0	1.9	1.8	1.7	4.3
W2		R	1.7	2.5	3.5	7.9	14.6
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
E1	Riccarton Road (East)	L	4.1	4.2	3.7	3.3	2.5
E2		T	12.3	12.1	11.0	9.8	7.2
S1	Matipo Street (South)	L	5.8	5.1	5.2	4.0	3.7
S2		R	3.7	3.0	3.0	2.3	1.5
W1	Riccarton Road (West)	T	6.6	6.3	5.9	6.2	27.3
W2		R	5.6	8.7	12.2	25.1	32.1

APPENDIX A11

Intersection 9 –Colombo Street/Peterborough Street Full Data

Table of Contents

A11.1 Approach Photos

Figure A11.1.1 - Peterborough Street East Approach

Figure A11.1.2 - Colombo Street North Approach

Figure A11.1.3 - Peterborough Street West Approach

Figure A11.1.4 - Colombo Street South Approach

A11.2 Surveyed Traffic Volume Data

Intersection 9: Colombo Street/Peterborough Street

Survey Date Monday, 2 October 2006

Light Vehicles			Colombo (South)			Peterborough (East)			Colombo (North)			Peterborough (West)			TOTAL
			L	T	R	L	T	R	L	T	R	L	T	R	
2:30	-	2:45	4	46	5	8	13	3	5	30	2	8	4	4	132
2:45	-	3:00	15	56	6	3	5	2	7	39	3	7	8	1	152
3:00	-	3:15	10	64	6	4	4	2	6	20	2	11	8	4	141
3:15	-	3:30	9	61	2	7	9	3	3	32	3	16	4	7	156
3:30	-	3:45	4	59	1	2	6	2	3	22	1	17	2	8	127
3:45	-	4:00	4	67	7	6	8	3	3	28	3	13	5	6	153

Heavy Vehicles			Colombo (South)			Peterborough (East)			Colombo (North)			Peterborough (West)			TOTAL
			L	T	R	L	T	R	L	T	R	L	T	R	
2:30	-	2:45	4	1	0	0	0	0	0	1	0	0	0	0	6
2:45	-	3:00	4	1	0	0	0	0	0	3	0	0	0	0	8
3:00	-	3:15	3	1	0	0	0	0	0	3	0	0	0	1	8
3:15	-	3:30	5	3	0	0	0	0	0	2	0	0	0	0	10
3:30	-	3:45	6	2	0	0	0	0	0	0	0	0	0	0	8
3:45	-	4:00	2	2	0	1	0	0	0	2	0	0	0	0	7

Total	Colombo (South)			Peterborough (East)			Colombo (North)			Peterborough (West)		
(2:30pm - 4:00pm)	L	T	R	L	T	R	L	T	R	L	T	R
Light	46	353	27	30	45	15	27	171	14	72	31	30
Heavy	24	10	0	1	0	0	0	11	0	0	0	1

Peak Hour	Colombo (South)			Peterborough (East)			Colombo (North)			Peterborough (West)		
(2:45pm - 3:45pm)	L	T	R	L	T	R	L	T	R	L	T	R
Light	38	240	15	16	24	9	19	113	9	51	22	20
Heavy	18	7	0	0	0	0	0	8	0	0	0	1

A11.3 Results Summary

A11.3.1 Journey Times Method 1

Figure A11.3.1 to Figure A11.3.5 present journey time comparisons for the right and left turn movements off the major road (Colombo Street) and for the average journey time for all movements through the intersection.

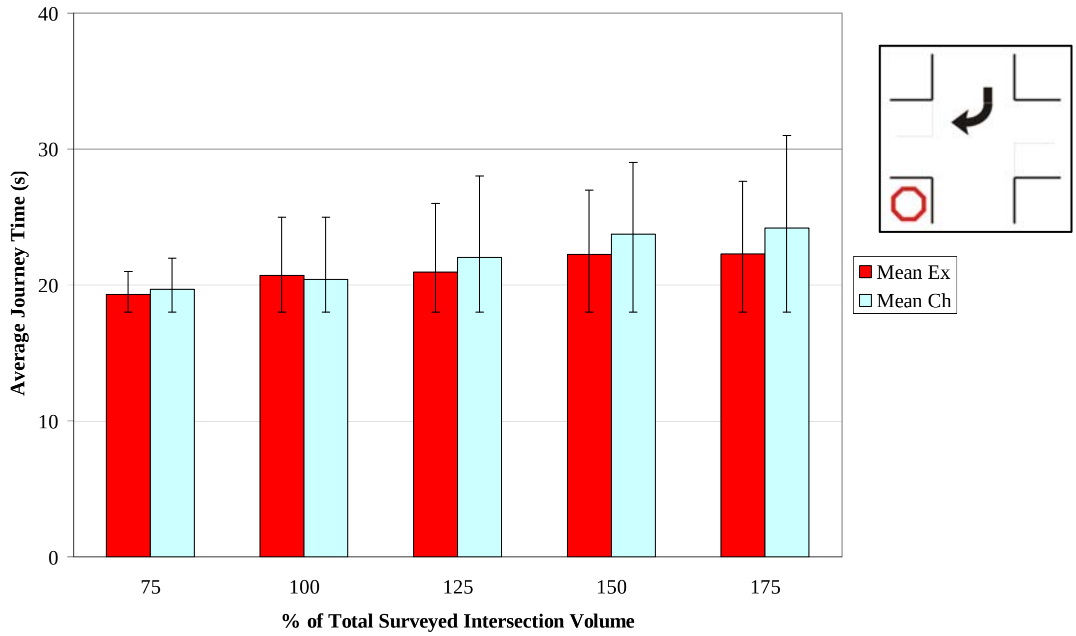


Figure A11.3.1 - Intersection 9, M1, Major Road (North) Right Turn Journey Time Comparison

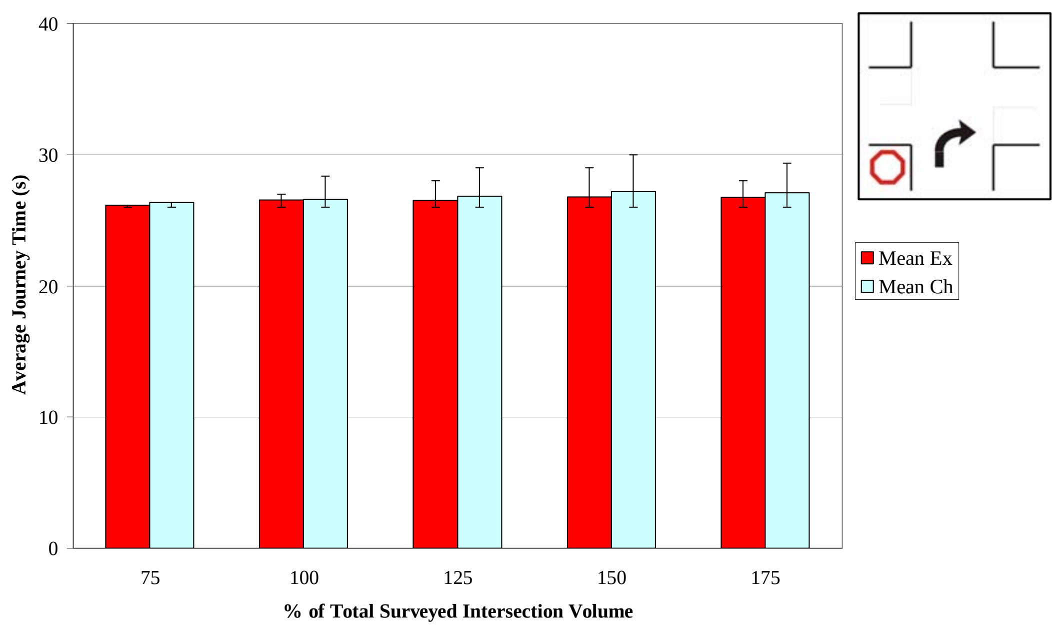


Figure A11.3.2 - Intersection 9, M1, Major Road (South) Right Turn Journey Time Comparison

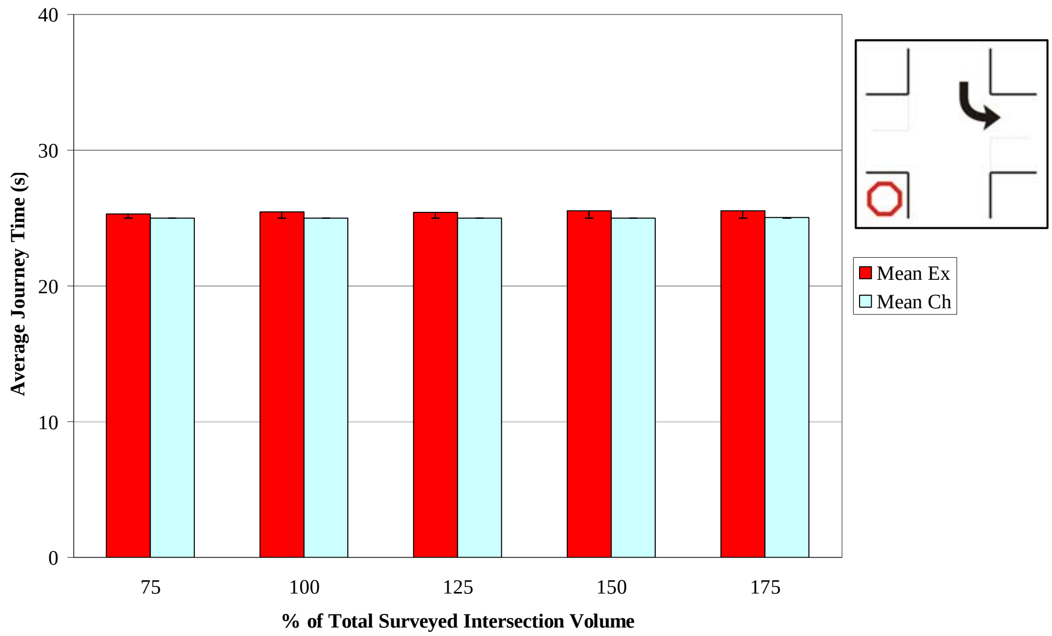


Figure A11.3.3 - Intersection 9, M1, Major Road (North) Left Turn Journey Time Comparison

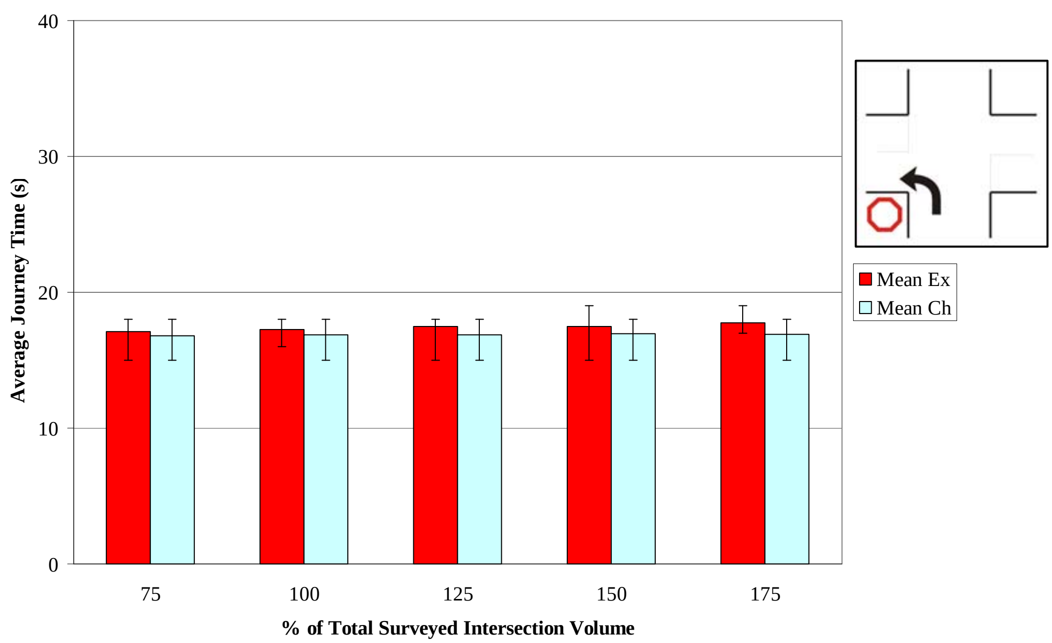


Figure A11.3.4 - Intersection 9, M1, Major Road (South) Left Turn Journey Time Comparison

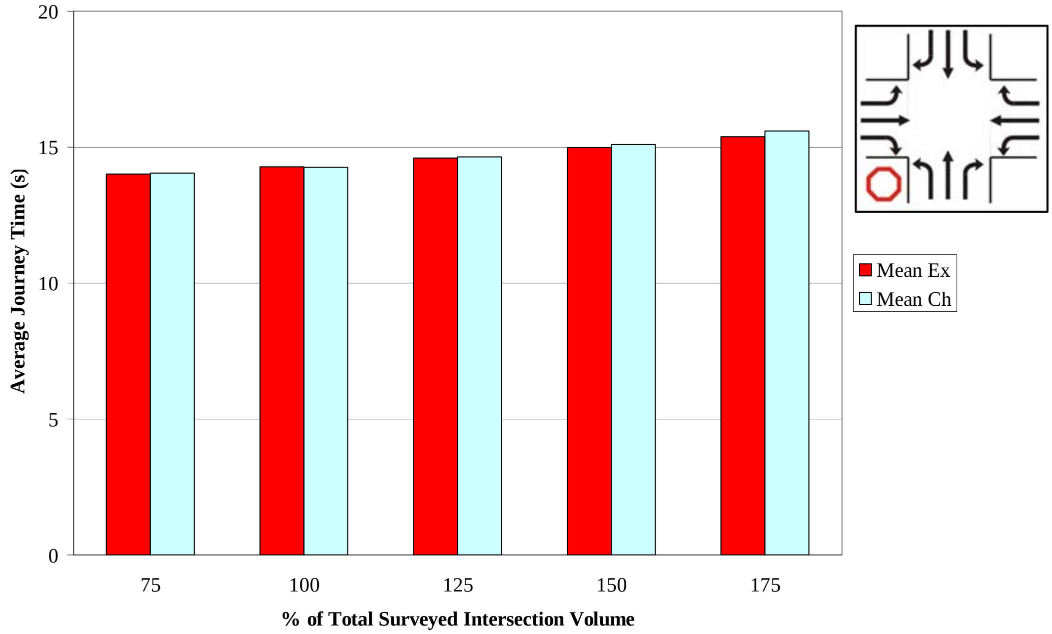


Figure A11.3.5 - Intersection 9, M1, Total Intersection Journey Time Comparison

A11.3.2 Journey Times Method 2

Figure A11.3.6 to Figure A11.3.10 present journey time comparisons for the right and left turn movements off the major road (Colombo Street) and for the overall journey time for all movements through the intersection.

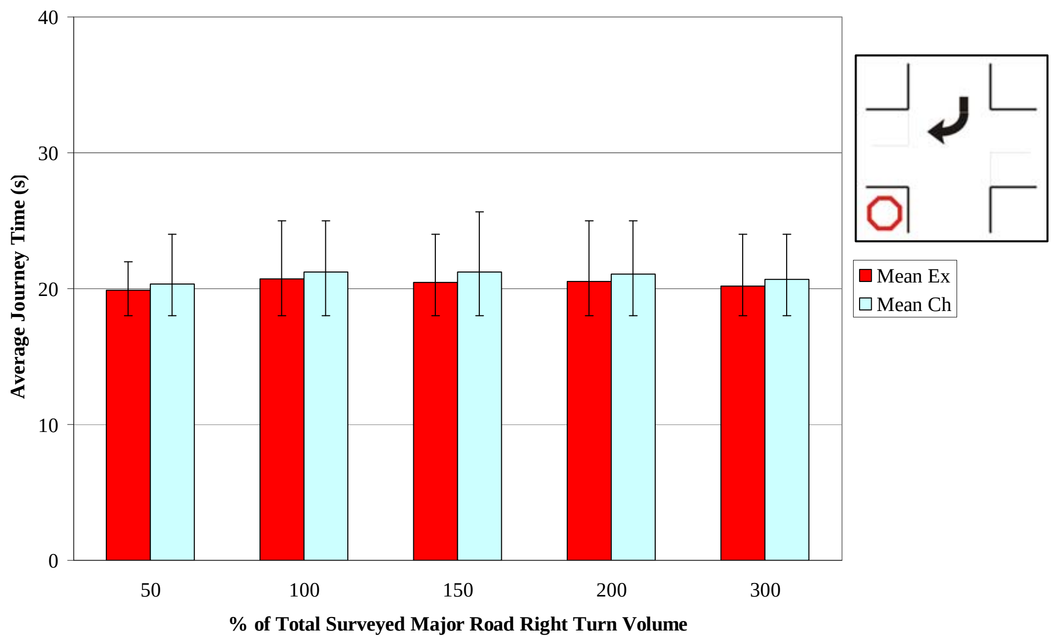


Figure A11.3.6 - Intersection 9, M2, Major Road (North) Right Turn Journey Time Comparison

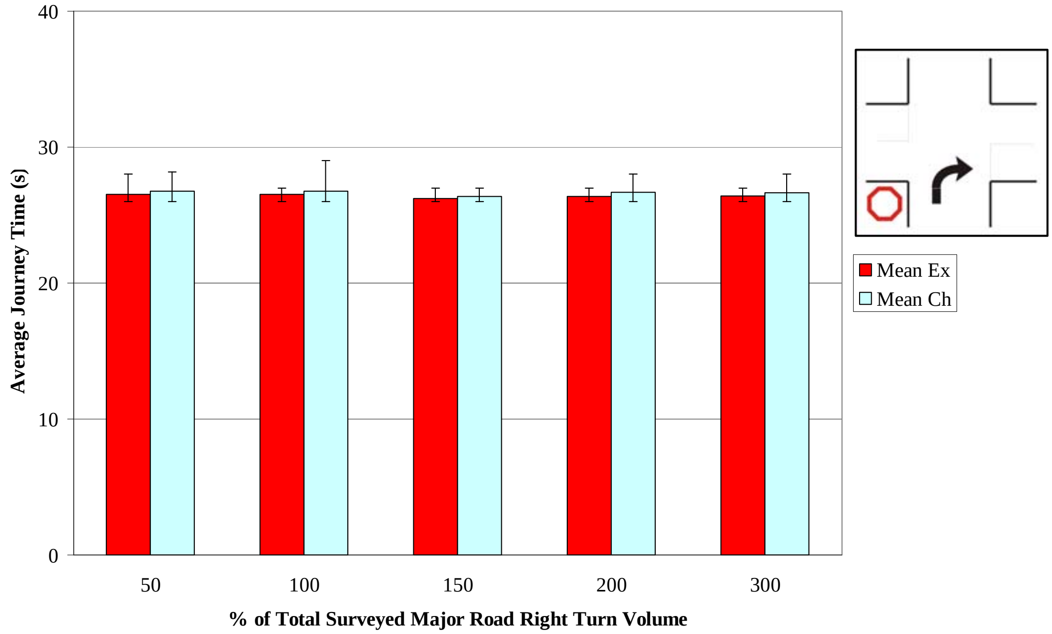


Figure A11.3.7 - Intersection 9, M2, Major Road (South) Right Turn Journey Time Comparison

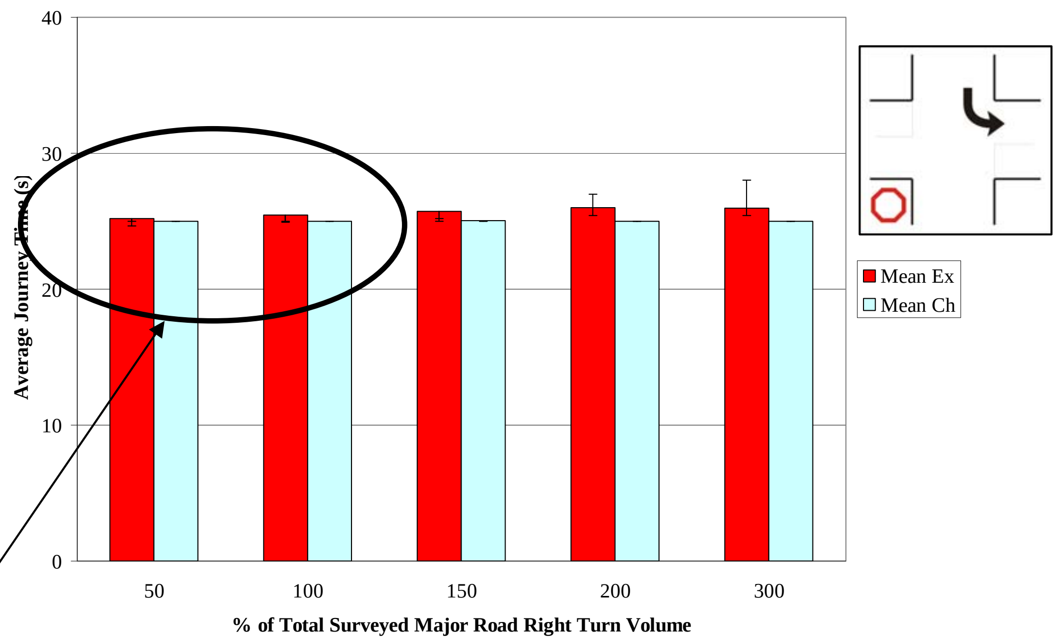


Figure A11.3.8 - Intersection 9, M2, Major Road (North) Left Turn Journey Time Comparison

It is noted that for the 50%, 100% and 150% scenarios the 85th percentile journey time is lower than the mean journey time. This is described in detail in Appendix A12, Section A12.3.1, where a similar result arises at Intersection 10.

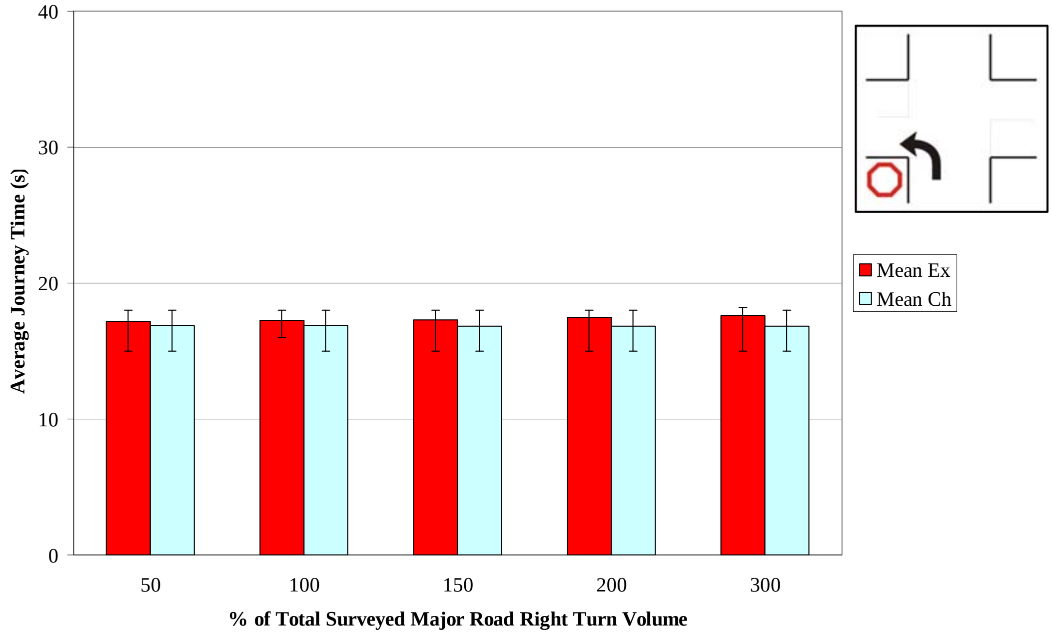


Figure A11.3.9 - Intersection 9, M2, Major Road (South) Left Turn Journey Time Comparison

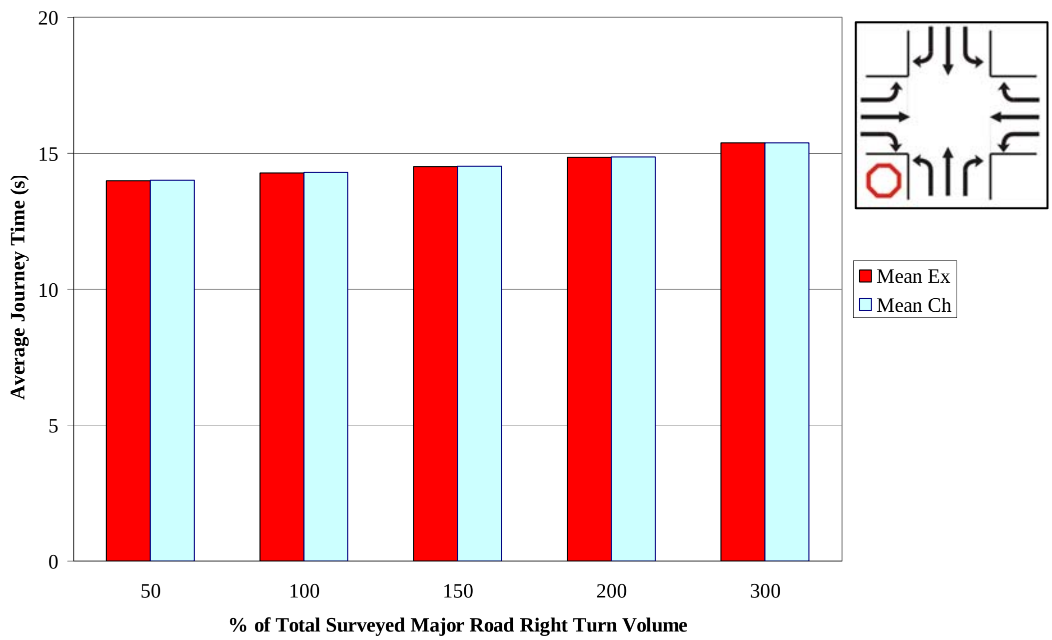


Figure A11.3.10 - Intersection 9, M2, Total Intersection Journey Time Comparison

Table A11.3.1 summarises the average journey times for all movements for each volume scenario.

Table A11.3.1 - Intersection 9, M2, Average Journey Time Comparison

Approach	Mvt	Average Journey Time (seconds/vehicle) for Various % Scenarios									
		50%		100%		150%		200%		300%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Colombo Street (North)	L	25	25	25	25	26	25	26	25	26	25
	T	10	10	10	10	10	10	10	10	10	10
	R	20	20	21	21	20	21	21	21	20	21
Peterborough Street (East)	L	23	23	23	23	23	23	23	23	23	23
	T	30	31	31	31	30	31	31	31	31	31
	R	24	24	24	24	25	25	25	25	26	26
Colombo Street (South)	L	17	17	17	17	17	17	17	17	18	17
	T	8	8	8	8	8	8	8	8	8	8
	R	27	27	27	27	26	26	26	27	26	27
Peterborough Street (West)	L	18	18	18	18	18	18	18	18	18	18
	T	31	31	31	31	32	32	32	32	33	33
	R	19	19	19	19	19	19	19	19	19	20
Total	All	14	14	14	14	15	15	15	15	15	15

Table A11.3.2 presents a summary of the increase or decrease in journey time for these two movements as a result of the rule change to nearside priority.

Table A11.3.2 - Intersection 9, M1, Right and Left Turn Average Journey Time Changes

Movement	Change in Average Journey Time (seconds/vehicle) for Various % Scenarios				
	75%	100%	125%	150%	175%
Colombo Street (North) R	0.5	0.5	0.7	0.5	0.5
Colombo Street (South) L	-0.3	-0.4	-0.5	-0.6	-0.8
Colombo Street (South) R	0.2	0.2	0.2	0.3	0.2
Colombo Street (North) L	-0.2	-0.5	-0.7	-1.0	-1.0

Table A11.3.2 illustrates that there is a consistent pattern through all the tested scenarios of the right turn journey time increasing by up to 0.5 seconds and the left turn journey time decreasing up to 1 second.

Overall there is very little difference between the two rules in terms of the overall journey time through the intersection.

A11.3.3 Queue Lengths Method 1

Figure A11.3.11 to Figure A11.3.16 present queue length comparisons for right and left turns off the major road, Colombo Street and for the minor road Peterborough Street approaches. It is noted that where a maximum queue length bar does not appear on the graph this is due to the maximum and average queue length being equal which can occur at low values.

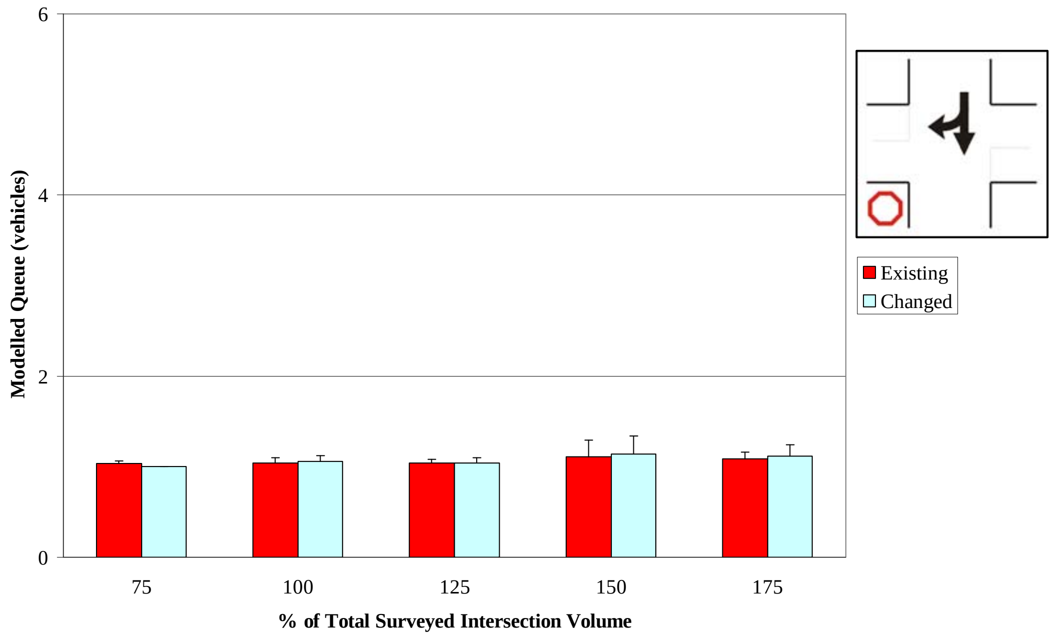


Figure A11.3.11 - Intersection 9, M1, Major Road (North) Through and Right Queue Comparison

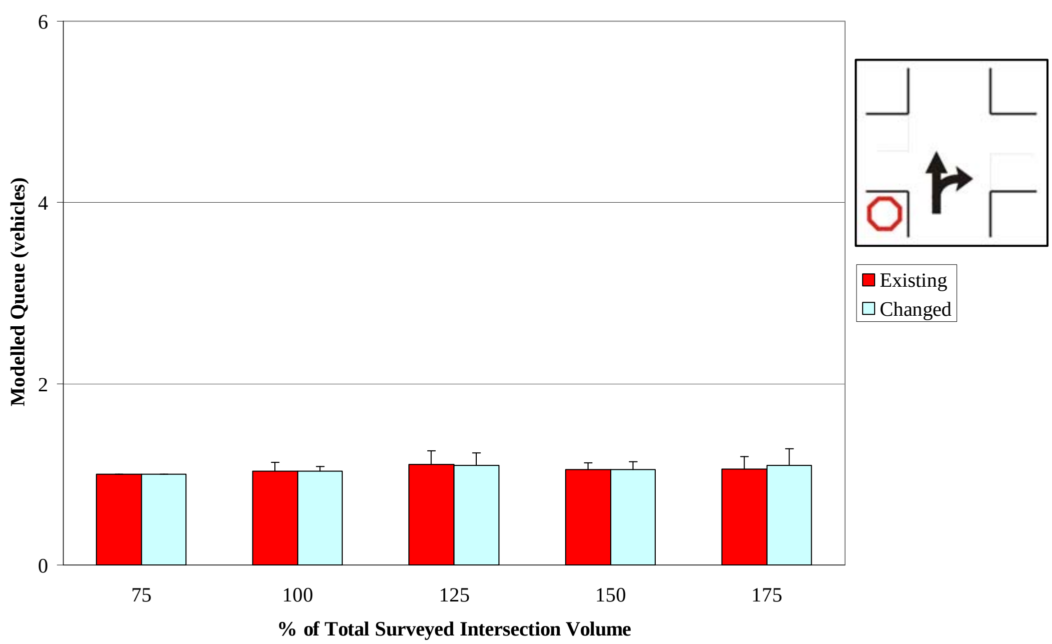


Figure A11.3.12 - Intersection 9, M1, Major Road (South) Through and Right Queue Comparison

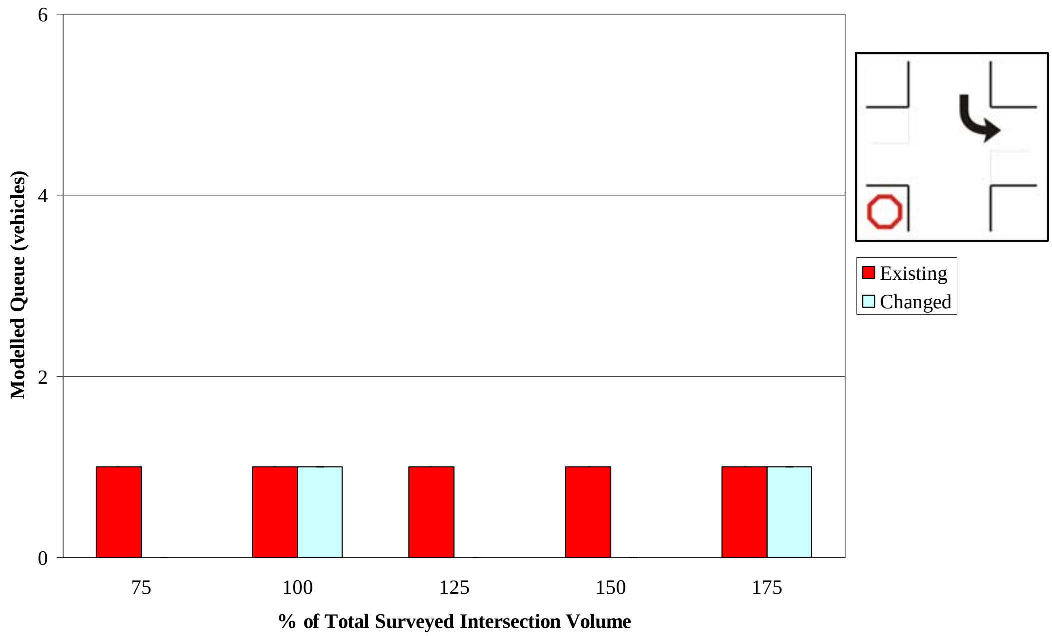


Figure A11.3.13 - Intersection 9, M1, Major Road (North) Left Turn Queue Comparison

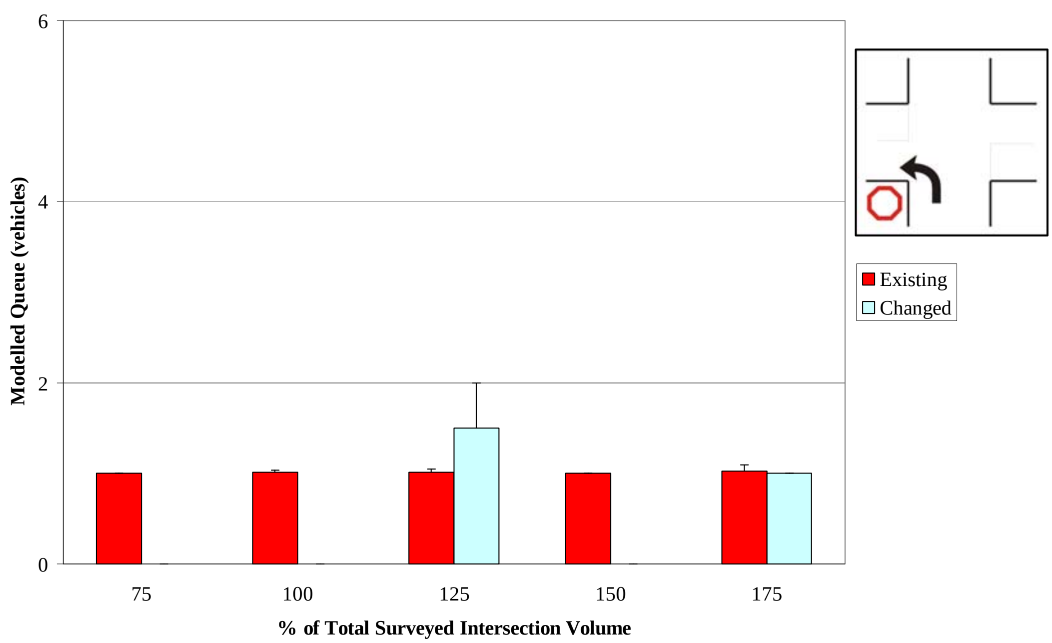


Figure A11.3.14 - Intersection 9, M1, Major Road (South) Left Turn Queue Comparison

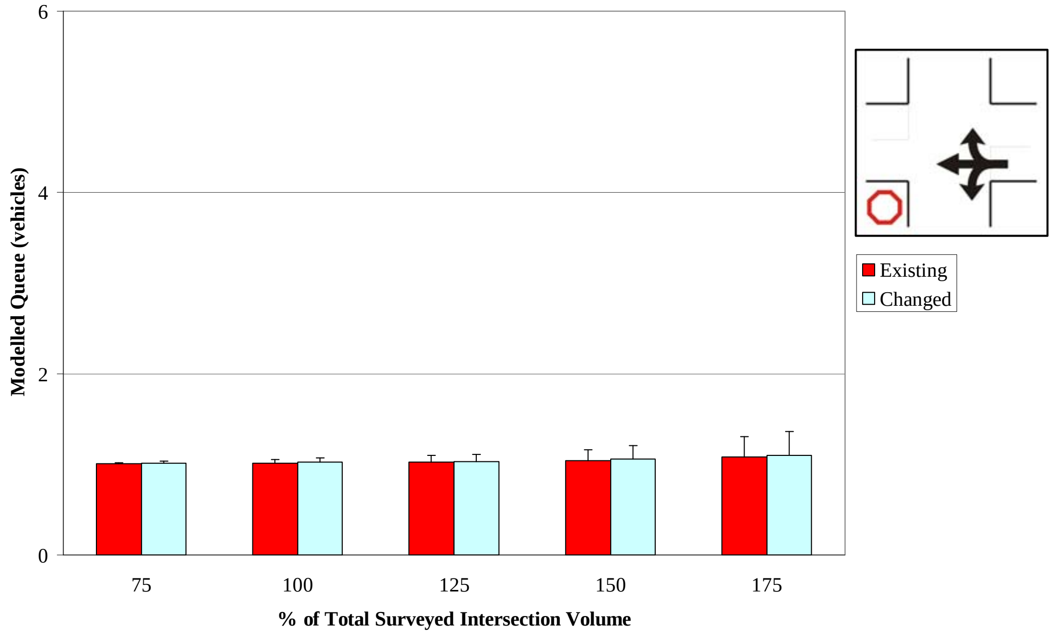


Figure A11.3.15 - Intersection 9, M1, Minor Road (East) Queue Comparison

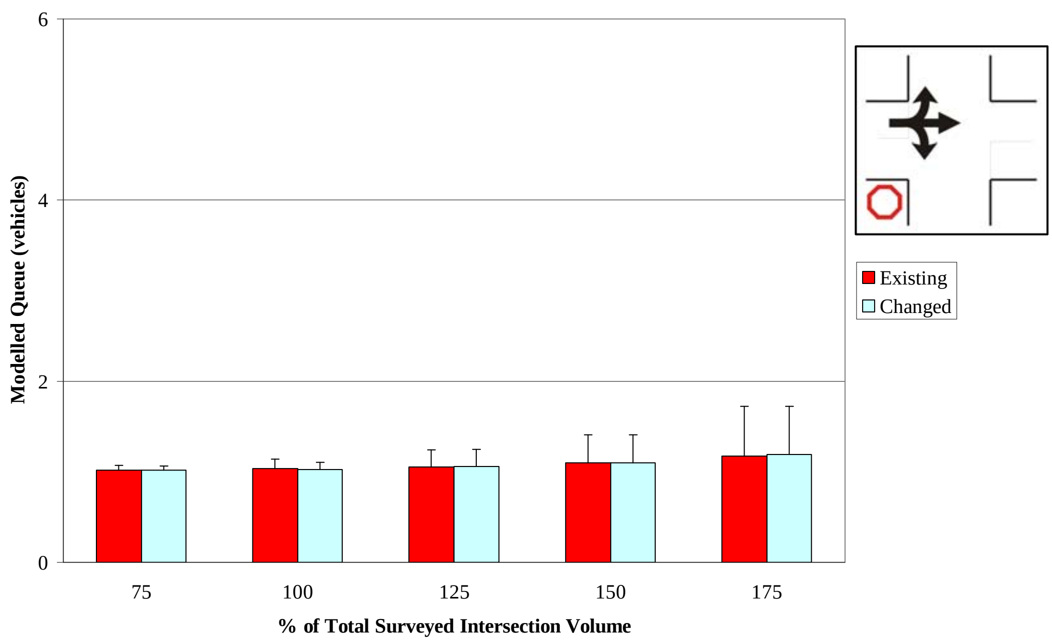


Figure A11.3.16 - Intersection 9, M1, Minor Road (West) Queue Comparison

A11.3.4 Queue Lengths Method 2

Figure A11.3.17 to Figure A11.3.22 present queue length comparisons for right and left turns off the major road, Colombo Street and for the minor road Peterborough Street approaches. It is noted that where a maximum queue length bar does not appear on the graph this is due to the maximum and average queue length being equal which can occur at low values.

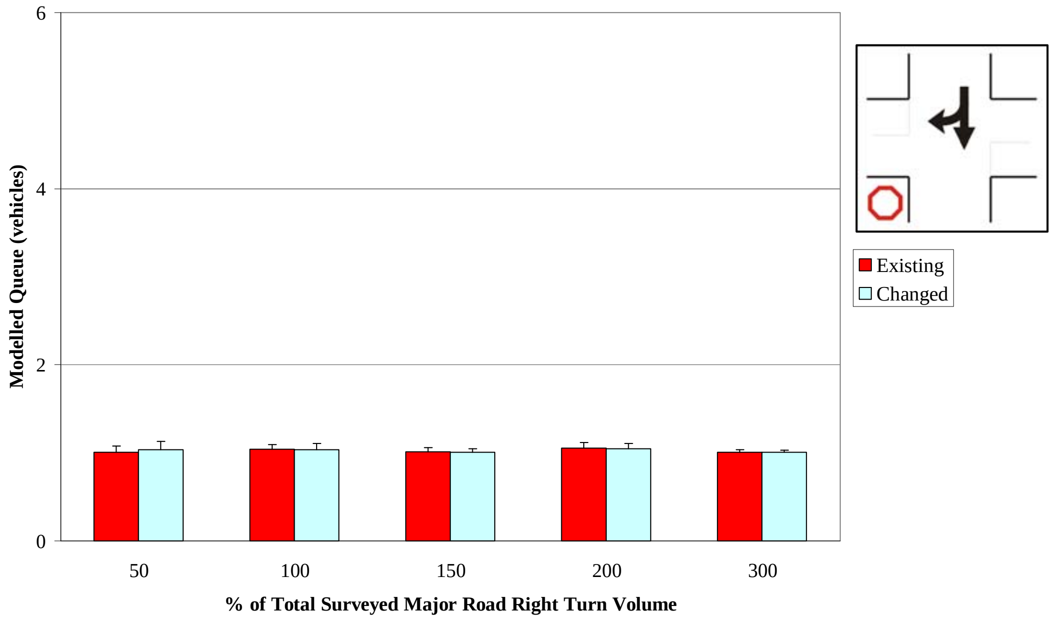


Figure A11.3.17 - Intersection 9, M2, Major Road (North) Through and Right Queue Comparison

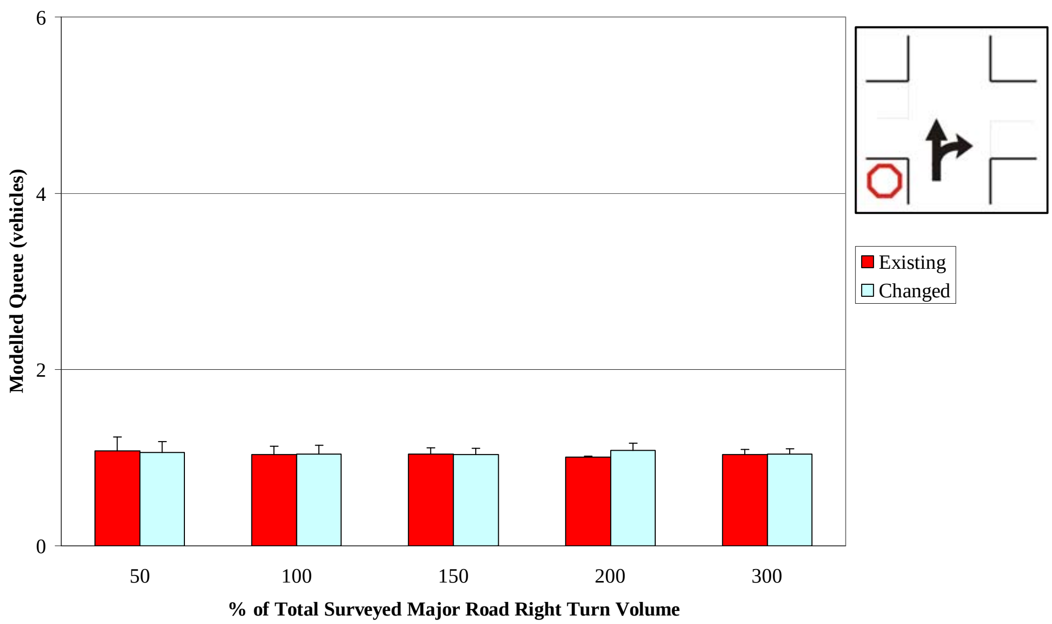


Figure A11.3.18 - Intersection 9, M2, Major Road (South) Through and Right Queue Comparison

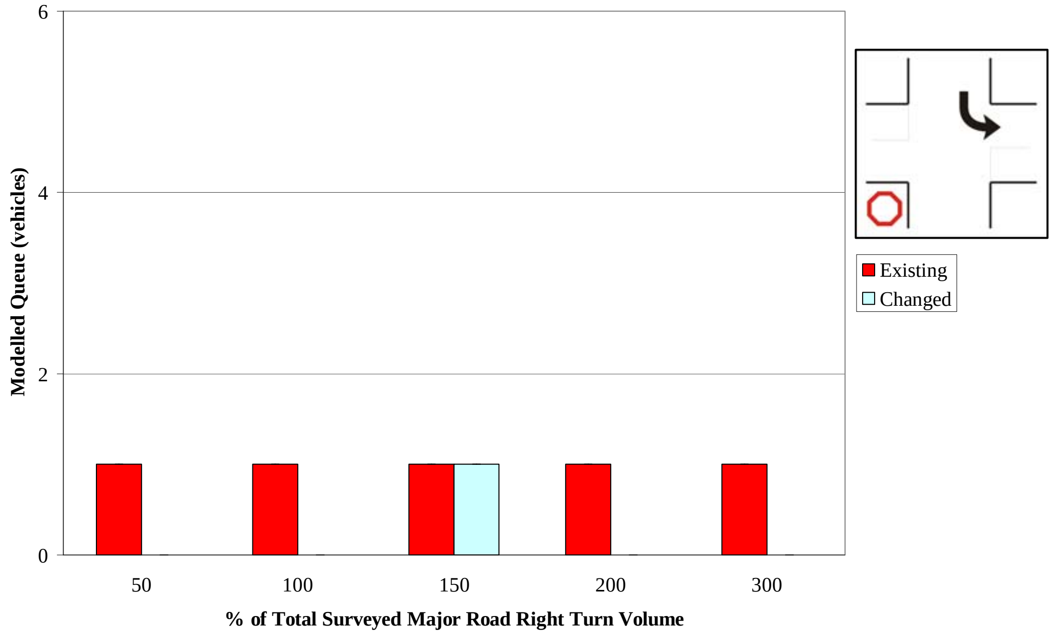


Figure A11.3.19 - Intersection 9, M2, Major Road (North) Left Turn Queue Comparison

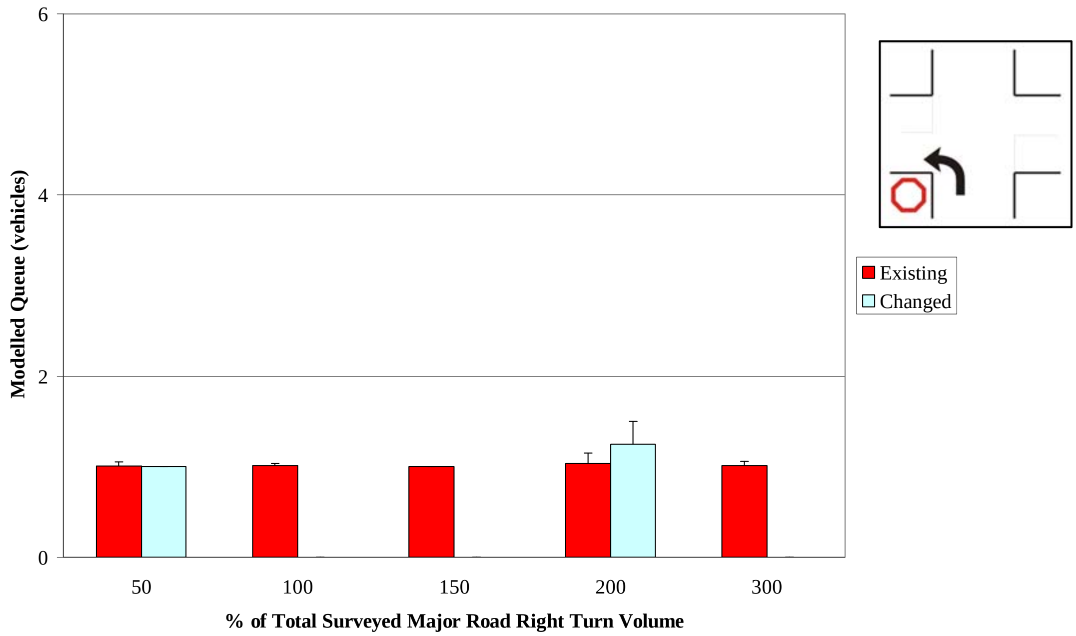


Figure A11.3.20 - Intersection 9, M2, Major Road (South) Left Turn Queue Comparison

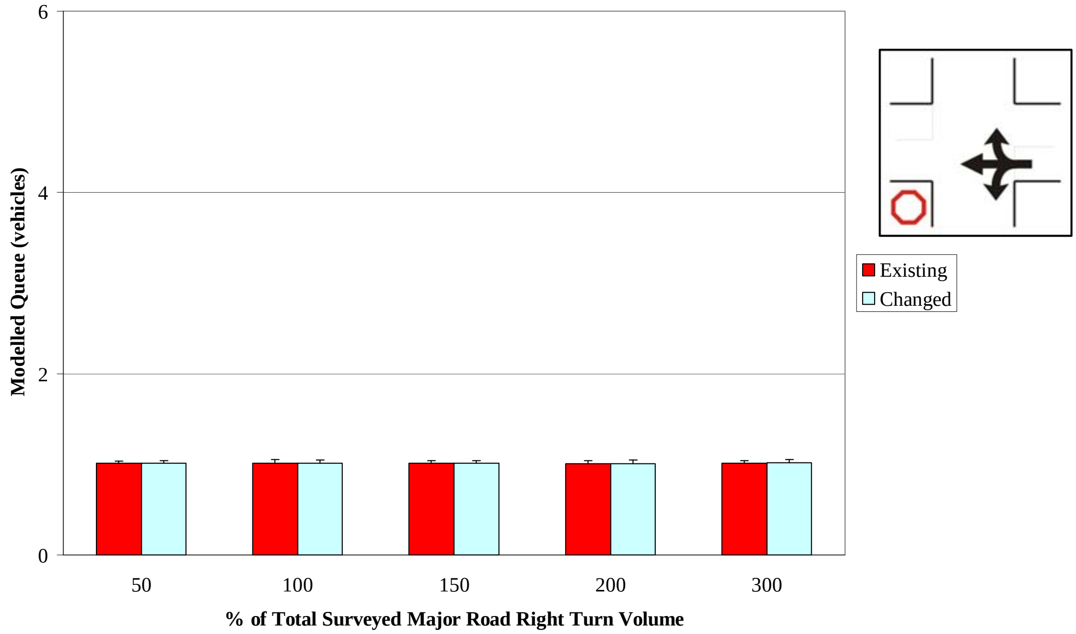


Figure A11.3.21 - Intersection 9, M2, Minor Road (East) Queue Comparison

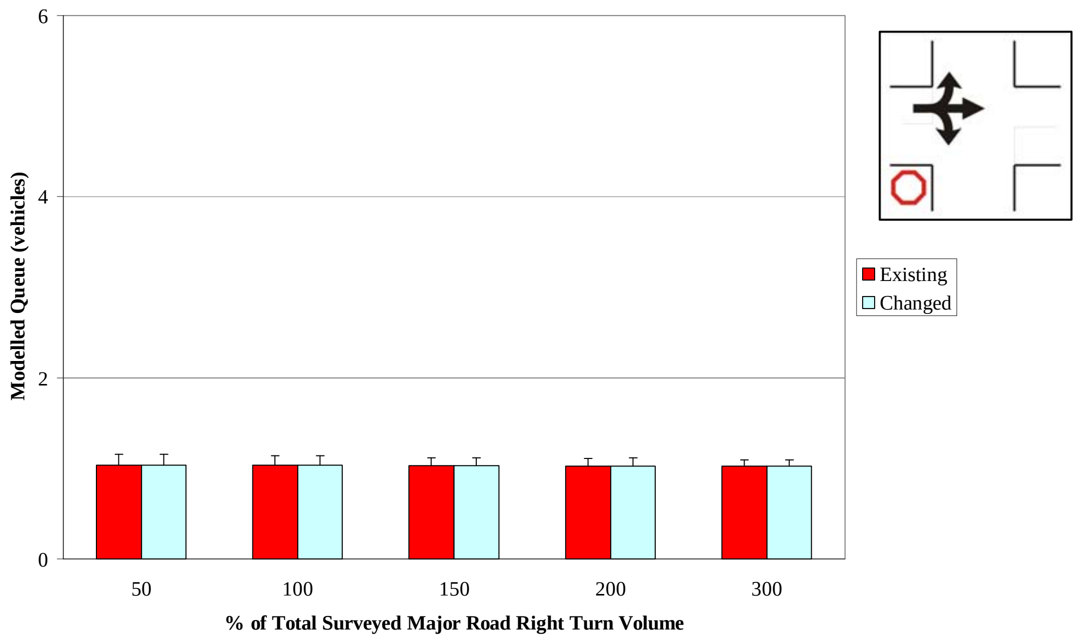


Figure A11.3.22 - Intersection 9, M2, Minor Road (West) Queue Comparison

Table A11.3.3 summarises the average queue lengths for all movements for each volume scenario.

Table A11.3.3 - Intersection 9, M2, Average Queue Comparison

Approach	Mvt	Average Queue Length (vehicles) for Various % Scenarios									
		50%		100%		150%		200%		300%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Colombo Street (North)	L	1.0	0.0	1.0	0.0	1.0	1.0	1.0	0.0	1.0	0.0
	TR	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.0
Peterborough Street (East)	LTR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Colombo Street (South)	L	1.0	1.0	1.0	0.0	1.0	0.0	1.0	1.3	1.0	0.0
	TR	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.1	1.0	1.0
Peterborough Street (West)	LTR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

The table shows there is very little difference between the two rules for any of the tested volume scenarios.

A11.4 Full Journey Time Analysis Results

Method 1 Existing Rule							
Mean Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Colombo Street (North)	L	25.3	25.5	25.4	25.5	25.5
NT		T	10.0	10.0	10.0	10.1	10.1
NR		R	19.3	20.7	20.9	22.3	22.3
EL	Peterborough Street (East)	L	22.3	22.6	23.5	24.1	25.1
ET		T	29.1	30.5	31.6	32.9	34.8
ER		R	24.1	24.4	25.8	26.8	29.3
SL	Colombo Street (South)	L	17.1	17.2	17.5	17.5	17.8
ST		T	8.1	8.1	8.2	8.2	8.3
SR		R	26.1	26.5	26.5	26.8	26.7
WL	Peterborough Street (West)	L	17.5	18.1	18.9	20.1	21.7
WT		T	30.5	31.3	32.4	34.4	36.2
WR		R	18.0	18.8	20.5	22.3	23.1
All Movements		All	14.0	14.3	14.6	15.0	15.4
Median Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Colombo Street (North)	L	25.0	25.0	25.0	25.0	25.0
NT		T	10.0	10.0	10.0	10.0	10.0
NR		R	18.0	18.0	18.0	21.0	21.0
EL	Peterborough Street (East)	L	22.0	22.0	22.0	22.0	23.0
ET		T	28.0	28.0	30.0	31.0	32.0
ER		R	23.0	23.0	24.0	25.0	26.0
SL	Colombo Street (South)	L	17.0	17.0	17.0	17.0	17.0
ST		T	8.0	8.0	8.0	8.0	8.0
SR		R	26.0	26.0	26.0	26.0	26.0
WL	Peterborough Street (West)	L	16.0	16.0	17.0	18.0	19.0
WT		T	29.0	29.0	30.0	32.0	33.0
WR		R	16.0	17.0	18.0	20.0	20.0
All Movements		All	10.0	10.0	10.0	10.0	10.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Colombo Street (North)	L	25.0	25.0	25.0	25.0	25.0
NT		T	10.0	10.0	10.0	10.0	10.0
NR		R	18.0	18.0	18.0	18.0	18.0
EL	Peterborough Street (East)	L	21.0	21.0	21.0	21.0	21.0
ET		T	27.0	27.0	27.0	27.0	28.0
ER		R	22.0	22.0	22.0	22.0	22.0
SL	Colombo Street (South)	L	15.0	16.0	15.0	15.0	17.0
ST		T	8.0	8.0	8.0	8.0	8.0
SR		R	26.0	26.0	26.0	26.0	26.0
WL	Peterborough Street (West)	L	16.0	16.0	16.0	16.0	16.0
WT		T	28.0	28.0	28.0	28.0	28.0
WR		R	16.0	16.0	16.0	16.0	16.0
All Movements		All	8.0	8.0	8.0	8.0	8.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Colombo Street (North)	L	25.0	25.0	25.0	25.0	25.0
NT		T	10.0	10.0	10.0	10.0	10.0
NR		R	21.0	25.0	26.0	27.0	27.7
EL	Peterborough Street (East)	L	24.0	24.0	27.0	27.0	29.0
ET		T	32.0	34.0	37.0	39.0	42.0
ER		R	27.0	26.5	30.0	33.0	37.0
SL	Colombo Street (South)	L	18.0	18.0	18.0	19.0	19.0
ST		T	8.0	8.0	8.0	8.0	9.0
SR		R	26.0	27.0	28.0	29.0	28.0
WL	Peterborough Street (West)	L	20.0	21.0	22.0	25.0	27.0
WT		T	34.0	35.0	37.5	41.0	46.0
WR		R	21.0	23.0	26.0	29.0	31.0
All Movements		All	25.0	25.0	25.0	26.0	26.0

Method 1 Changed Rule							
Mean Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Colombo Street (North)	L	25.0	25.0	25.0	25.0	25.0
NT		T	10.0	10.1	10.1	10.1	10.2
NR		R	19.7	20.4	22.0	23.7	24.2
EL	Peterborough Street (East)	L	22.4	22.7	23.7	24.5	25.6
ET		T	29.9	30.9	32.6	34.6	37.1
ER		R	24.1	25.0	26.1	27.2	29.9
SL	Colombo Street (South)	L	16.8	16.9	16.9	16.9	16.9
ST		T	8.1	8.1	8.2	8.2	8.3
SR		R	26.3	26.6	26.8	27.2	27.1
WL	Peterborough Street (West)	L	17.4	18.0	19.0	20.1	22.0
WT		T	30.2	31.1	32.6	34.8	37.5
WR		R	18.1	19.1	20.4	22.3	23.5
All Movements		All	14.0	14.3	14.6	15.1	15.6
Median Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Colombo Street (North)	L	25.0	25.0	25.0	25.0	25.0
NT		T	10.0	10.0	10.0	10.0	10.0
NR		R	18.0	18.0	19.0	23.0	22.0
EL	Peterborough Street (East)	L	22.0	22.0	22.0	22.0	23.0
ET		T	28.0	29.0	31.0	32.0	34.0
ER		R	23.0	23.0	24.0	25.0	27.0
SL	Colombo Street (South)	L	17.0	17.0	17.0	17.0	17.0
ST		T	8.0	8.0	8.0	8.0	8.0
SR		R	26.0	26.0	26.0	26.0	26.0
WL	Peterborough Street (West)	L	16.0	17.0	17.0	18.0	20.0
WT		T	28.0	29.0	31.0	32.0	34.0
WR		R	16.0	17.0	18.0	20.0	20.0
All Movements		All	10.0	10.0	10.0	10.0	10.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Colombo Street (North)	L	25.0	25.0	25.0	25.0	25.0
NT		T	10.0	10.0	10.0	10.0	10.0
NR		R	18.0	18.0	18.0	18.0	18.0
EL	Peterborough Street (East)	L	21.0	21.0	21.0	21.0	21.0
ET		T	27.0	27.0	27.0	27.0	28.0
ER		R	22.0	22.0	22.0	22.0	22.0
SL	Colombo Street (South)	L	15.0	15.0	15.0	15.0	15.0
ST		T	8.0	8.0	8.0	8.0	8.0
SR		R	26.0	26.0	26.0	26.0	26.0
WL	Peterborough Street (West)	L	16.0	16.0	16.0	16.0	16.0
WT		T	28.0	28.0	28.0	28.0	28.0
WR		R	16.0	16.0	16.0	16.0	16.0
All Movements		All	8.0	8.0	8.0	8.0	8.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Colombo Street (North)	L	25.0	25.0	25.0	25.0	25.0
NT		T	10.0	10.0	10.0	10.0	10.0
NR		R	22.0	25.0	28.0	29.0	31.0
EL	Peterborough Street (East)	L	24.0	25.0	27.0	28.0	31.0
ET		T	33.0	36.0	39.0	41.0	47.0
ER		R	26.7	28.4	30.4	34.0	38.0
SL	Colombo Street (South)	L	18.0	18.0	18.0	18.0	18.0
ST		T	8.0	8.0	8.0	8.0	8.0
SR		R	26.0	28.4	29.0	30.0	29.4
WL	Peterborough Street (West)	L	20.0	21.0	22.0	25.0	28.0
WT		T	34.0	35.0	38.0	42.0	48.0
WR		R	22.0	23.0	26.0	29.4	32.0
All Movements		All	25.0	25.0	25.0	26.0	26.0

Method 2 Existing Rule							
Mean Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Colombo Street (North)	L	25.2	25.5	25.7	26.0	26.0
NT		T	10.0	10.0	10.0	10.1	10.0
NR		R	19.9	20.7	20.5	20.5	20.2
EL	Peterborough Street (East)	L	22.9	22.6	22.6	22.8	22.6
ET		T	30.0	30.5	30.2	30.6	30.7
ER		R	24.3	24.4	24.9	24.7	25.7
SL	Colombo Street (South)	L	17.2	17.2	17.3	17.5	17.6
ST		T	8.1	8.1	8.1	8.2	8.2
SR		R	26.5	26.5	26.2	26.4	26.4
WL	Peterborough Street (West)	L	18.1	18.1	18.1	18.2	18.0
WT		T	31.1	31.3	31.5	31.6	32.6
WR		R	18.8	18.8	18.9	19.3	19.4
All Movements		All	14.0	14.3	14.5	14.8	15.4
Median Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Colombo Street (North)	L	25.0	25.0	25.0	25.0	25.0
NT		T	10.0	10.0	10.0	10.0	10.0
NR		R	18.0	18.0	18.0	18.0	18.0
EL	Peterborough Street (East)	L	22.0	22.0	22.0	22.0	22.0
ET		T	28.0	28.0	28.0	29.0	28.0
ER		R	23.0	23.0	23.0	23.0	24.0
SL	Colombo Street (South)	L	17.0	17.0	17.0	17.0	17.0
ST		T	8.0	8.0	8.0	8.0	8.0
SR		R	26.0	26.0	26.0	26.0	26.0
WL	Peterborough Street (West)	L	17.0	16.0	16.0	17.0	16.0
WT		T	29.0	29.0	29.0	29.0	30.0
WR		R	17.0	17.0	17.0	17.0	17.0
All Movements		All	10.0	10.0	10.0	10.0	10.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Colombo Street (North)	L	25.0	25.0	25.0	25.0	25.0
NT		T	10.0	10.0	10.0	10.0	10.0
NR		R	18.0	18.0	18.0	18.0	18.0
EL	Peterborough Street (East)	L	21.0	21.0	21.0	21.0	21.0
ET		T	27.0	27.0	27.0	27.0	27.0
ER		R	22.0	22.0	22.0	22.0	22.0
SL	Colombo Street (South)	L	15.0	16.0	15.0	15.0	15.0
ST		T	8.0	8.0	8.0	8.0	8.0
SR		R	26.0	26.0	26.0	26.0	26.0
WL	Peterborough Street (West)	L	16.0	16.0	16.0	16.0	16.0
WT		T	28.0	28.0	28.0	28.0	28.0
WR		R	16.0	16.0	16.0	16.0	16.0
All Movements		All	8.0	8.0	8.0	8.0	8.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Colombo Street (North)	L	25.0	25.0	25.0	27.0	28.0
NT		T	10.0	10.0	10.0	10.0	10.0
NR		R	22.0	25.0	24.0	25.0	24.0
EL	Peterborough Street (East)	L	25.0	24.0	24.9	25.0	25.0
ET		T	33.0	34.0	34.0	35.0	35.0
ER		R	28.0	26.5	29.7	28.7	30.0
SL	Colombo Street (South)	L	18.0	18.0	18.0	18.0	18.2
ST		T	8.0	8.0	8.0	8.0	8.0
SR		R	28.0	27.0	27.0	27.0	27.0
WL	Peterborough Street (West)	L	21.0	21.0	21.0	21.0	21.0
WT		T	35.0	35.0	36.0	36.0	38.0
WR		R	23.0	23.0	23.0	24.0	24.0
All Movements		All	25.0	25.0	25.0	26.0	26.0

Method 2 Changed Rule							
Mean Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Colombo Street (North)	L	25.0	25.0	25.0	25.0	25.0
NT		T	10.0	10.0	10.1	10.1	10.1
NR		R	20.4	21.2	21.2	21.1	20.7
EL	Peterborough Street (East)	L	22.9	22.6	22.6	22.8	22.8
ET		T	30.7	31.0	30.9	31.1	31.3
ER		R	24.3	24.4	24.8	24.8	25.7
SL	Colombo Street (South)	L	16.9	16.9	16.8	16.8	16.8
ST		T	8.1	8.1	8.1	8.2	8.2
SR		R	26.8	26.8	26.4	26.7	26.7
WL	Peterborough Street (West)	L	18.1	18.1	18.1	18.2	18.0
WT		T	31.3	31.4	31.8	31.8	32.8
WR		R	18.9	18.9	18.9	19.3	19.5
All Movements		All	14.0	14.3	14.5	14.9	15.4
Median Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Colombo Street (North)	L	25.0	25.0	25.0	25.0	25.0
NT		T	10.0	10.0	10.0	10.0	10.0
NR		R	18.0	20.0	18.0	18.0	18.0
EL	Peterborough Street (East)	L	22.0	22.0	22.0	22.0	22.0
ET		T	28.0	29.0	29.0	29.0	29.0
ER		R	23.0	23.0	23.0	23.0	24.0
SL	Colombo Street (South)	L	17.0	17.0	17.0	17.0	17.0
ST		T	8.0	8.0	8.0	8.0	8.0
SR		R	26.0	26.0	26.0	26.0	26.0
WL	Peterborough Street (West)	L	17.0	16.0	16.0	17.0	16.0
WT		T	29.0	29.0	30.0	29.0	30.0
WR		R	17.0	17.0	17.0	17.0	17.0
All Movements		All	10.0	10.0	10.0	10.0	10.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Colombo Street (North)	L	25.0	25.0	25.0	25.0	25.0
NT		T	10.0	10.0	10.0	10.0	10.0
NR		R	18.0	18.0	18.0	18.0	18.0
EL	Peterborough Street (East)	L	21.0	21.0	21.0	21.0	21.0
ET		T	27.0	27.0	27.0	27.0	27.0
ER		R	22.0	22.0	22.0	22.0	22.0
SL	Colombo Street (South)	L	15.0	15.0	15.0	15.0	15.0
ST		T	8.0	8.0	8.0	8.0	8.0
SR		R	26.0	26.0	26.0	26.0	26.0
WL	Peterborough Street (West)	L	16.0	16.0	16.0	16.0	16.0
WT		T	28.0	28.0	28.0	28.0	28.0
WR		R	16.0	16.0	16.0	16.0	16.0
All Movements		All	8.0	8.0	8.0	8.0	8.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Colombo Street (North)	L	25.0	25.0	25.0	25.0	25.0
NT		T	10.0	10.0	10.0	10.0	10.0
NR		R	24.0	25.0	25.7	25.0	24.0
EL	Peterborough Street (East)	L	25.0	24.0	24.9	25.0	25.0
ET		T	35.0	36.0	35.0	36.0	36.0
ER		R	28.0	27.0	29.7	28.7	30.0
SL	Colombo Street (South)	L	18.0	18.0	18.0	18.0	18.0
ST		T	8.0	8.0	8.0	8.0	8.0
SR		R	28.2	29.0	27.0	28.0	28.0
WL	Peterborough Street (West)	L	21.0	21.0	21.0	21.0	21.0
WT		T	36.0	35.0	36.6	37.0	38.0
WR		R	24.0	23.0	23.0	24.0	24.0
All Movements		All	25.0	25.0	25.0	26.0	26.0

A11.5 Full Queue Length Analysis Results

Method 1							
Existing Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Colombo Street (North)	L	1.0	1.0	1.0	1.0	1.0
N2		TR	1.0	1.0	1.0	1.1	1.1
E1	Peterborough Street (East)	LTR	1.0	1.0	1.0	1.0	1.1
S1	Colombo Street (South)	L	1.0	1.0	1.0	1.0	1.0
S2		TR	1.0	1.0	1.1	1.1	1.1
W1	Peterborough Street (West)	LTR	1.0	1.0	1.1	1.1	1.2
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Colombo Street (North)	L	1.0	1.0	1.0	1.0	1.0
N2		TR	1.1	1.1	1.1	1.3	1.2
E1	Peterborough Street (East)	LTR	1.0	1.1	1.1	1.2	1.3
S1	Colombo Street (South)	L	1.0	1.0	1.0	1.0	1.1
S2		TR	1.0	1.1	1.3	1.1	1.2
W1	Peterborough Street (West)	LTR	1.1	1.1	1.2	1.4	1.7
Changed Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Colombo Street (North)	L	0.0	1.0	0.0	0.0	1.0
N2		TR	1.0	1.1	1.0	1.1	1.1
E1	Peterborough Street (East)	LTR	1.0	1.0	1.0	1.1	1.1
S1	Colombo Street (South)	L	0.0	0.0	1.5	0.0	1.0
S2		TR	1.0	1.0	1.1	1.1	1.1
W1	Peterborough Street (West)	LTR	1.0	1.0	1.1	1.1	1.2
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Colombo Street (North)	L	0.0	1.0	0.0	0.0	1.0
N2		TR	1.0	1.1	1.1	1.3	1.2
E1	Peterborough Street (East)	LTR	1.0	1.1	1.1	1.2	1.4
S1	Colombo Street (South)	L	0.0	0.0	2.0	0.0	1.0
S2		TR	1.0	1.1	1.2	1.1	1.3
W1	Peterborough Street (West)	LTR	1.1	1.1	1.3	1.4	1.7

Method 2							
Existing Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Colombo Street (North)	L	1.0	1.0	1.0	1.0	1.0
N2		TR	1.0	1.0	1.0	1.1	1.0
E1	Peterborough Street (East)	LTR	1.0	1.0	1.0	1.0	1.0
S1	Colombo Street (South)	L	1.0	1.0	1.0	1.0	1.0
S2		TR	1.1	1.0	1.0	1.0	1.0
W1	Peterborough Street (West)	LTR	1.0	1.0	1.0	1.0	1.0
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Colombo Street (North)	L	1.0	1.0	1.0	1.0	1.0
N2		TR	1.1	1.1	1.1	1.1	1.0
E1	Peterborough Street (East)	LTR	1.0	1.1	1.0	1.0	1.0
S1	Colombo Street (South)	L	1.1	1.0	1.0	1.1	1.1
S2		TR	1.2	1.1	1.1	1.0	1.1
W1	Peterborough Street (West)	LTR	1.2	1.1	1.1	1.1	1.1
Changed Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Colombo Street (North)	L	0.0	0.0	1.0	0.0	0.0
N2		TR	1.0	1.0	1.0	1.0	1.0
E1	Peterborough Street (East)	LTR	1.0	1.0	1.0	1.0	1.0
S1	Colombo Street (South)	L	1.0	0.0	0.0	1.3	0.0
S2		TR	1.1	1.0	1.0	1.1	1.0
W1	Peterborough Street (West)	LTR	1.0	1.0	1.0	1.0	1.0
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Colombo Street (North)	L	0.0	0.0	1.0	0.0	0.0
N2		TR	1.1	1.1	1.1	1.1	1.0
E1	Peterborough Street (East)	LTR	1.0	1.0	1.0	1.0	1.1
S1	Colombo Street (South)	L	1.0	0.0	0.0	1.5	0.0
S2		TR	1.2	1.1	1.1	1.2	1.1
W1	Peterborough Street (West)	LTR	1.2	1.1	1.1	1.1	1.1

APPENDIX A12

Intersection 10 –Main South Road/Halswell Junction Road Full Data

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Table of Contents

A12.1 Approach Photos

Figure A12.1.1 - Halswell Junction Road North Approach

Figure A12.1.3 - Halswell Junction Road South Approach

Figure A12.1.2 - Main South Road East Approach

Figure A12.1.4 - Main South Road West Approach

A12.2 Surveyed Traffic Volume Data

Intersection 10: Halswell Junction Road/Main South Road

Survey Date Wednesday, 8 November 2006

Light Vehicles			Halswell Junction (South)			Main South (East)			Halswell Junction (North)			Main South (West)			TOTAL
			L	T	R	L	T	R	L	T	R	L	T	R	
4:30	-	4:45	32	5	2	5	140	5	6	19	28	17	140	1	400
4:45	-	5:00	13	4	2	7	77	1	12	62	12	8	145	22	365
5:00	-	5:15	37	17	7	38	106	12	27	21	13	6	145	18	447
5:15	-	5:30	47	7	3	23	117	23	31	12	7	22	165	43	500
5:30	-	5:45	52	11	12	67	145	17	59	0	12	28	160	45	608
5:45	-	6:00	57	4	7	22	102	43	47	7	13	8	105	17	432

Heavy Vehicles			Halswell Junction (South)			Main South (East)			Halswell Junction (North)			Main South (West)			TOTAL
			L	T	R	L	T	R	L	T	R	L	T	R	
4:30	-	4:45	4	0	0	1	2	2	2	30	6	0	0	0	47
4:45	-	5:00	1	0	0	1	2	2	0	0	3	0	0	0	9
5:00	-	5:15	22	0	0	0	15	3	12	0	0	1	29	3	85
5:15	-	5:30	22	3	0	0	20	0	22	3	0	11	38	3	122
5:30	-	5:45	22	7	1	3	22	2	27	3	1	7	27	31	153
5:45	-	6:00	12	2	3	2	33	2	17	3	2	2	31	2	111

Total	Halswell Junction (South)			Main South (East)			Halswell Junction (North)			Main South (West)		
(4:30pm - 6:00pm)	L	T	R	L	T	R	L	T	R	L	T	R
Light	238	48	33	162	687	101	182	121	85	89	860	146
Heavy	83	12	4	7	94	11	80	39	12	21	125	39

Peak Hour	Halswell Junction (South)			Main South (East)			Halswell Junction (North)			Main South (West)		
(4:45pm - 5:45pm)	L	T	R	L	T	R	L	T	R	L	T	R
Light	149	39	24	135	445	53	129	95	44	64	615	128
Heavy	67	10	1	4	59	7	61	6	4	19	94	37

A12.3 Results Summary

A12.3.1 Journey Times Method 1

Figure A12.3.1 and Figure A12.3.2 present the average journey times for the right turns off the major road (Main South Road).

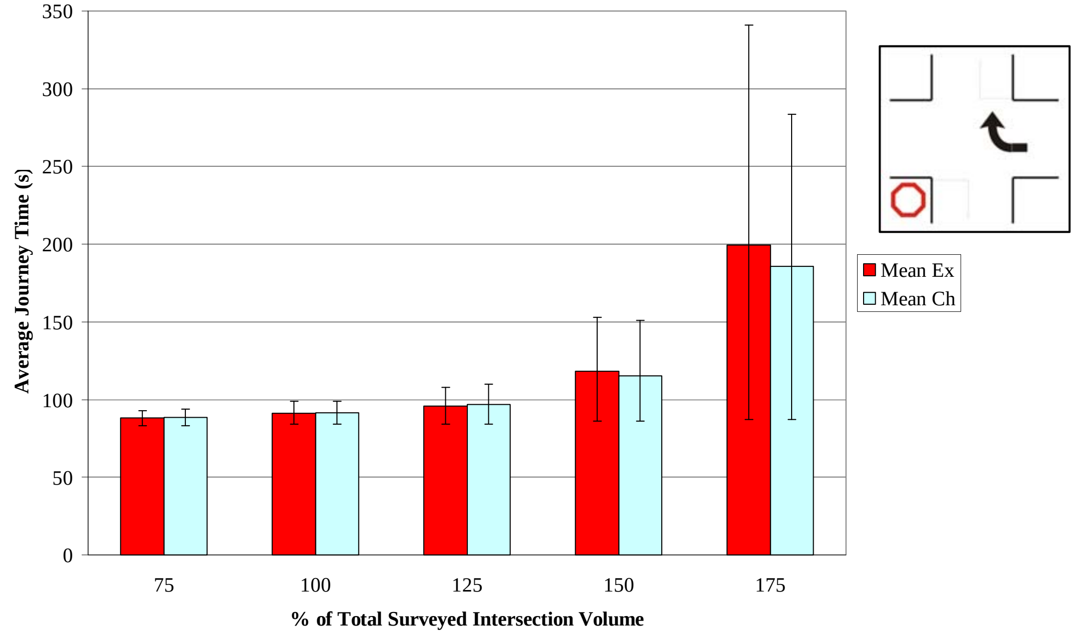

Figure A12.3.1 - Intersection 10, M1, Major Road (East) Right Turn Journey Time Comparison

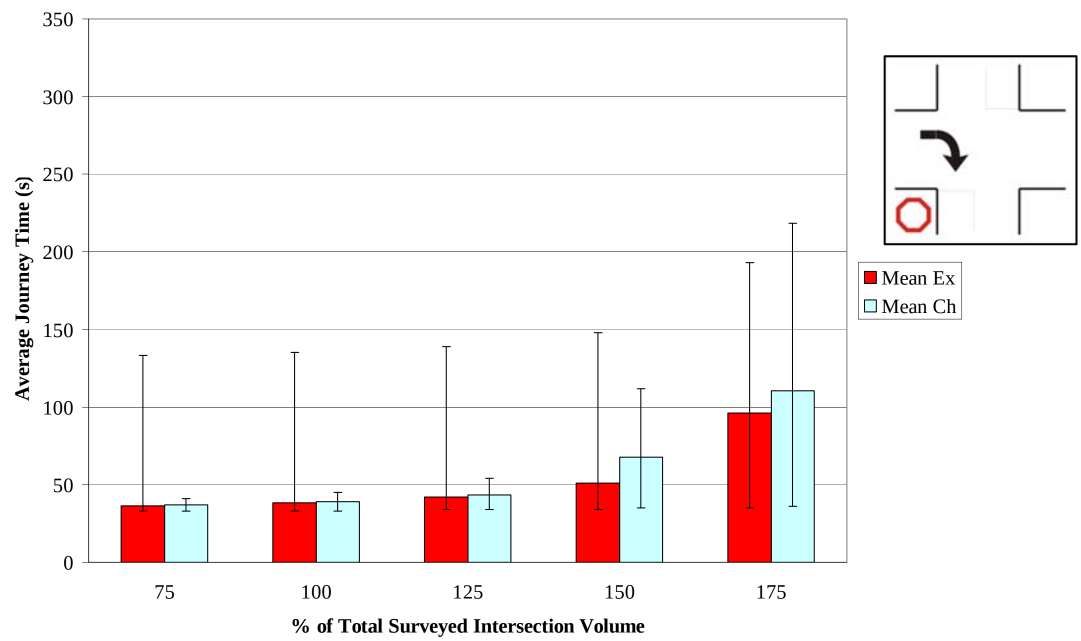

Figure A12.3.2 - Intersection 10, M1, Major Road (West) Right Turn Journey Time Comparison

Figure A12.3.3 presents the average journey times for the left turns off the east approach of the major road (Main South Road (East)).

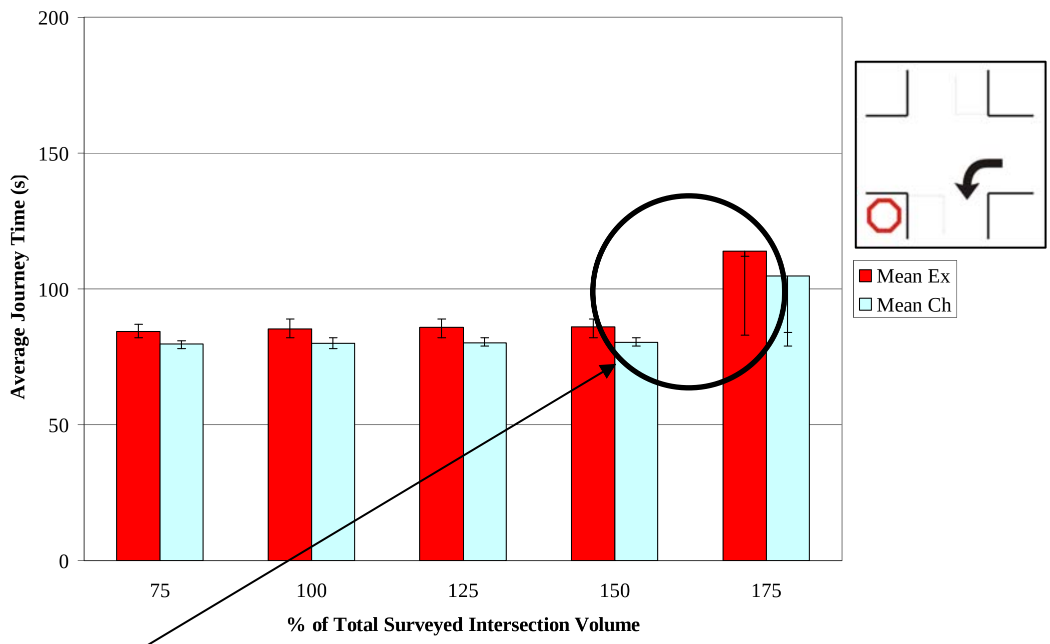

Figure A12.3.3 - Intersection 10, M1, Major Road (East) Left Turn Journey Time Comparison

Figure A12.3.3 shows that the 85th percentile journey time is less than the mean journey time for the 175% scenario which does not seem intuitively correct. Table A12.3.1presents the summary statistics for this scenario.

Table A12.3.1 - Summary Statistics Major Road (East) Left Turn, Intersection 10, M1, 175%

Measure	Existing	Changed
Mean Journey Time (s)	114	105
15th Percentile (s)	83	79
85th Percentile (s)	112	84
Median Journey Time (s)	86	81

Under both the existing and changed rules the mean journey time is higher than the 85th percentile. The median journey times are both less than the 85th percentile which confirms the analysis is statistically correct. The mean journey time is the sum of all modelled journey times divided by the total number of journeys modelled.

Figure A12.3.4 presents all the modelled journey times for the left turn off Main South Road (East) from the ten modelled runs. The journey times are presented in ascending order. The mean and 85th percentile values are also plotted on the graph. For clarity, Figure A12.3.5 presents an enlargement of the same graph.

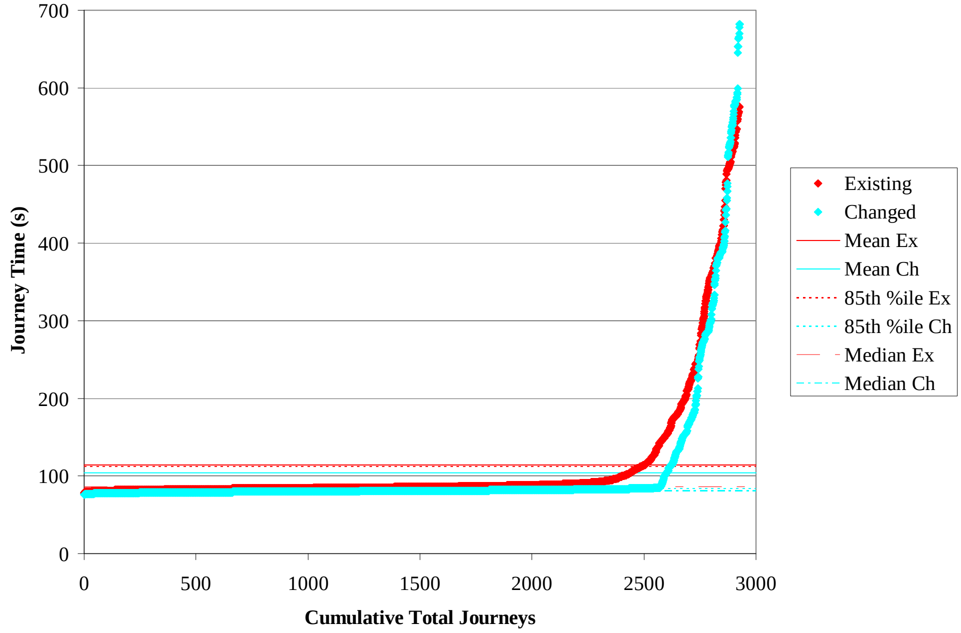

Figure A12.3.4 - All Modelled Journey Times East Left Turn (Intersection 10, M1, 175%)

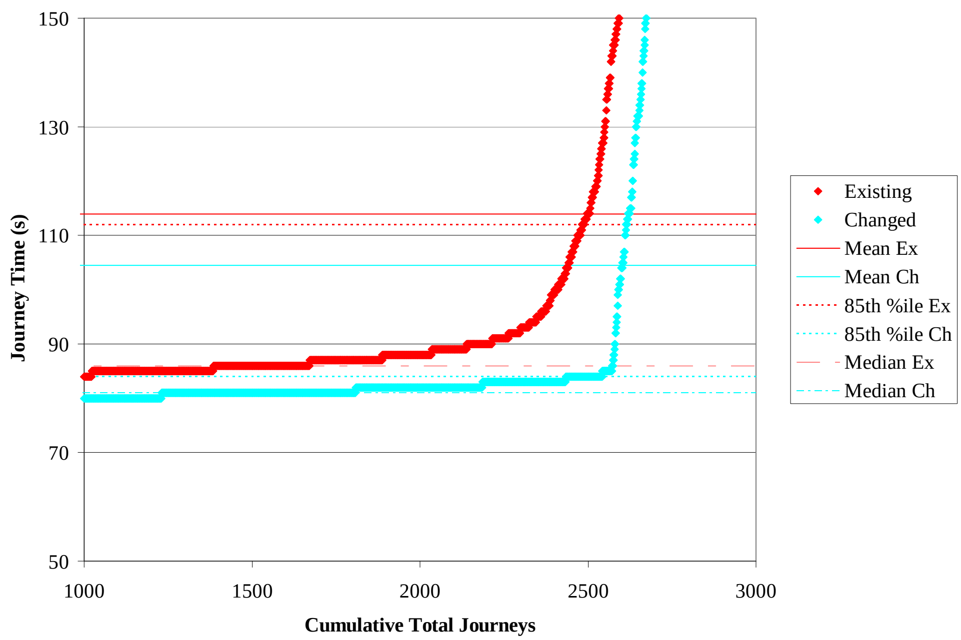

Figure A12.3.5 - Enlargement of All Modelled Journey Times East Left Turn (Intersection 10, M1, 175%)

It is evident that is both cases there are a very high proportion, approximately 2,000 of the modelled 3,000 journeys that have the same journey time of around 80 seconds. This is approximately the free-flow travel time for this movement and the high number of vehicles with this modelled time reflects that a high proportion of vehicles undertaking this movement do so with little or no interaction with other traffic.

The enlarged graph clearly illustrates that under the changed rule where the left turn becomes an unopposed movement, there are more vehicles with this free-flow journey time. Under the existing rule some of these vehicles would coincide with a right turning vehicle and be required to yield priority.

The high proportion of these vehicles effectively pulls the 85th percentile journey time down to be below the mean. This is exaggerated under the changed rule, as shown on the graphs, by the greater number of unopposed left turners.

Figure A12.3.6 presents the average journey times for the left turns off the east approach of the major road (Main South Road (West)).

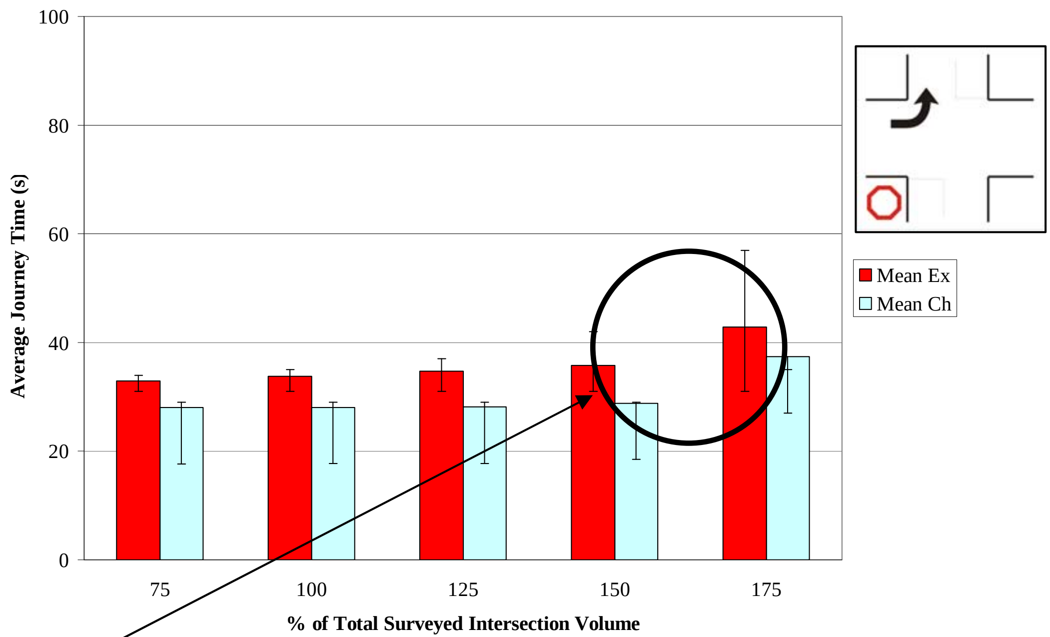

Figure A12.3.6 - Intersection 10, M1, Major Road (West) Left Turn Journey Time Comparison

Figure A12.3.6 shows that under the 175% scenario and the changed rule the 85th percentile value is less than the mean value for the same reason as described above for the left turn movement from the Main South Road (East) approach.

Figure A12.3.7 presents the average journey time for all movements through the intersection under each rule and volume scenario.

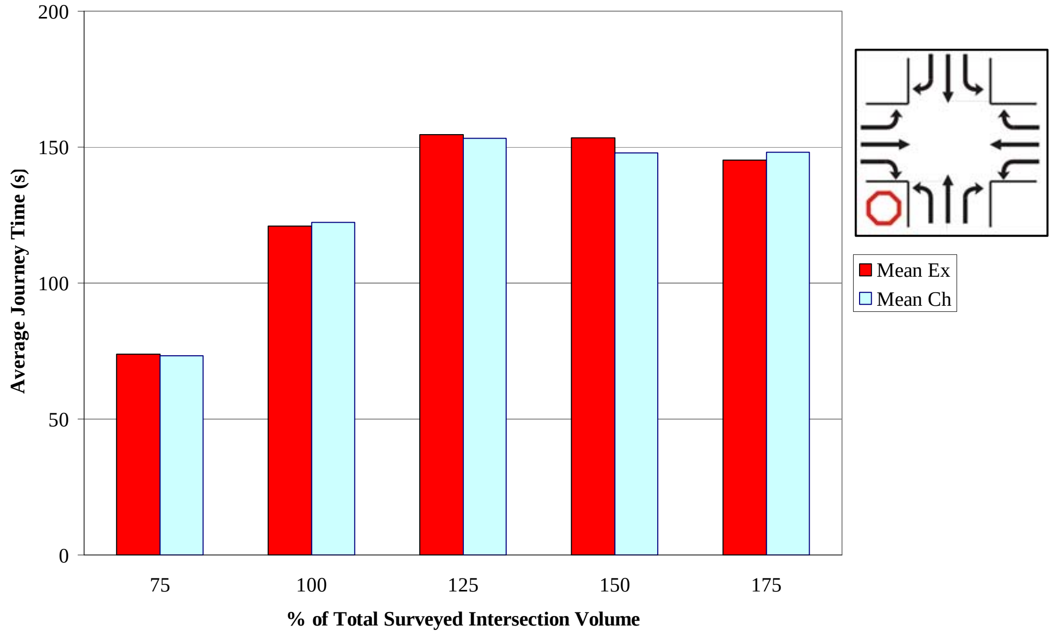

Figure A12.3.7 - Intersection 10, M1, Total Intersection Journey Time Comparison

A12.3.2 Journey Times Method 2

Figure A12.3.7 to Figure A12.3.12 present the average journey times for the right and left turns off the major road (Main South Road) and also the average journey time for all movements through the intersection.

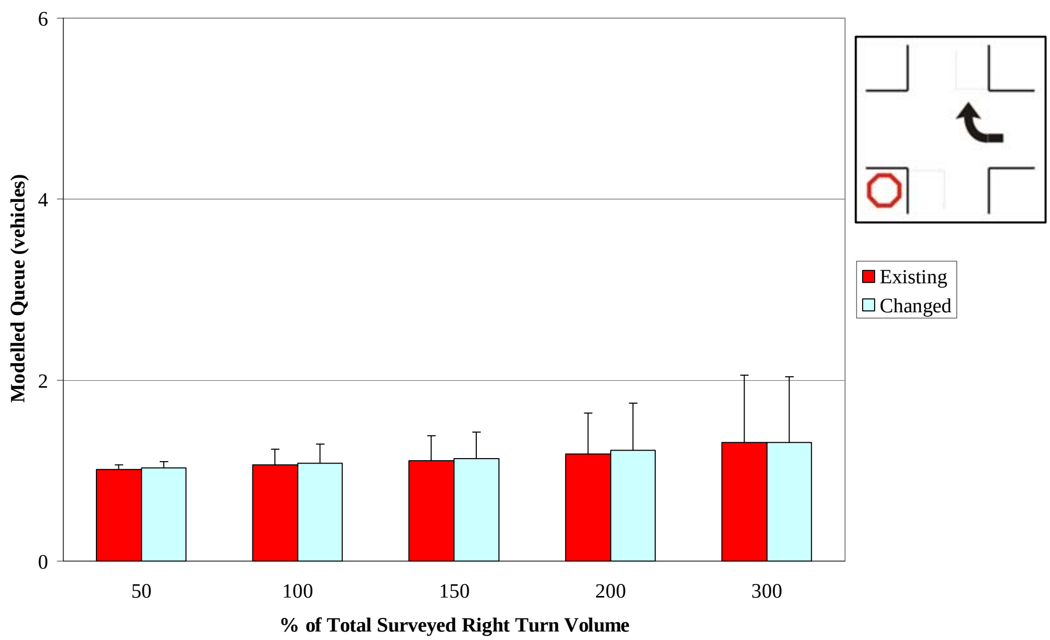

Figure A12.3.8 - Intersection 10, M2, Major Road (East) Right Turn Journey Time Comparison

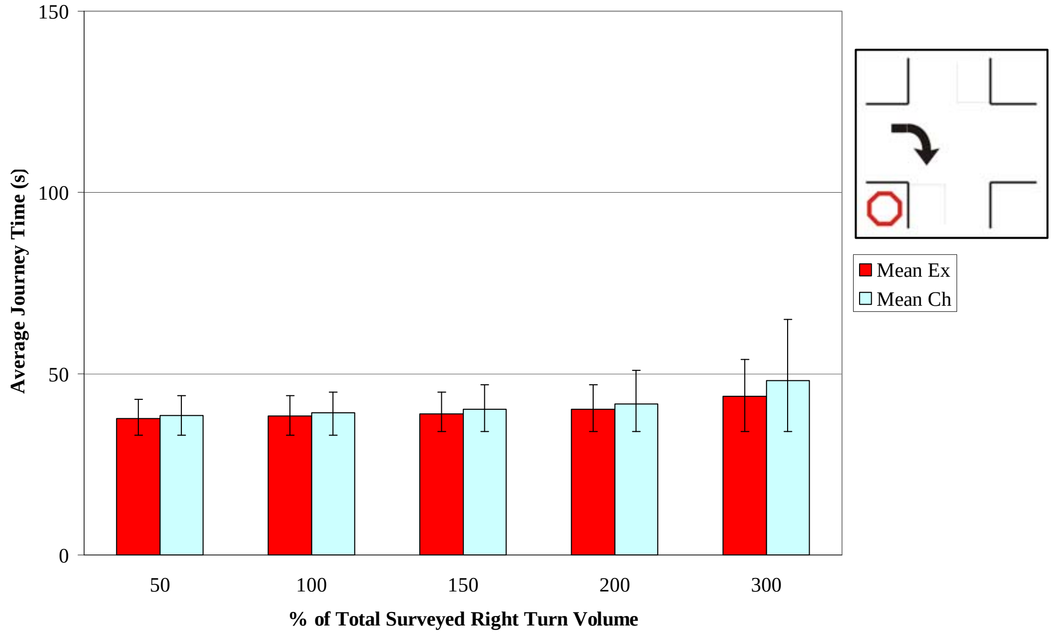

Figure A12.3.9 - Intersection 10, M2, Major Road (West) Right Turn Journey Time Comparison

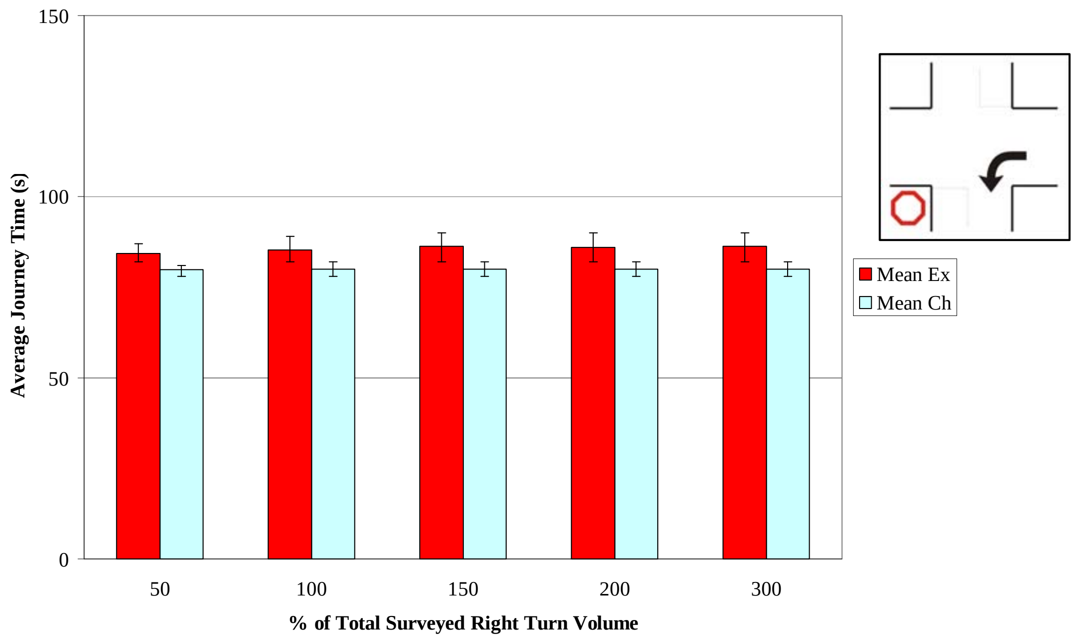

Figure A12.3.10 - Intersection 10, M2, Major Road (East) Left Turn Journey Time Comparison

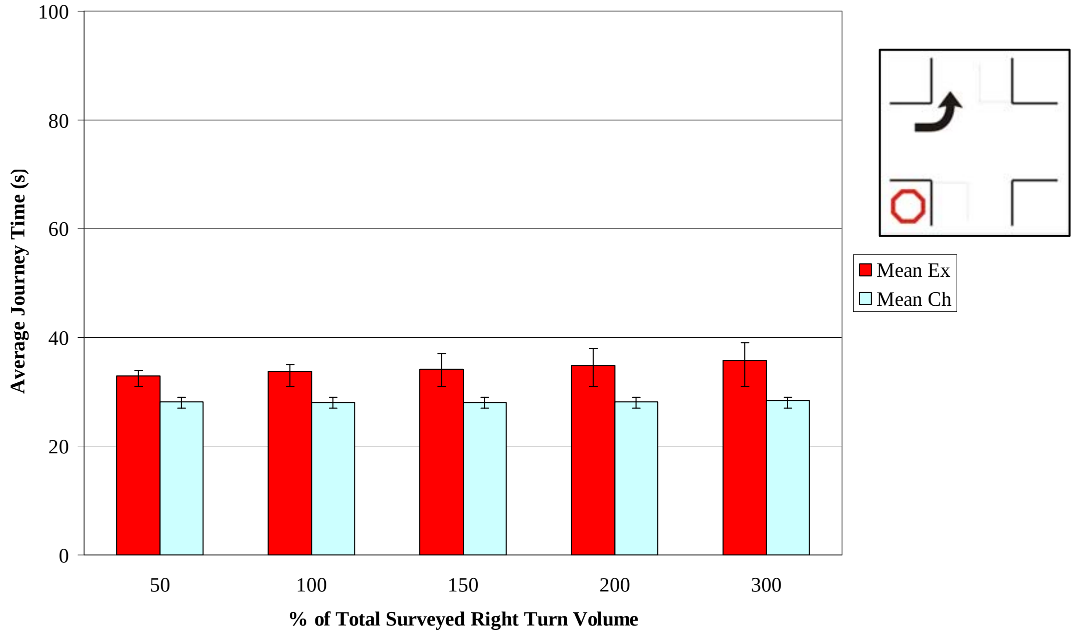

Figure A12.3.11 - Intersection 10, M2, Major Road (West) Left Turn Journey Time Comparison

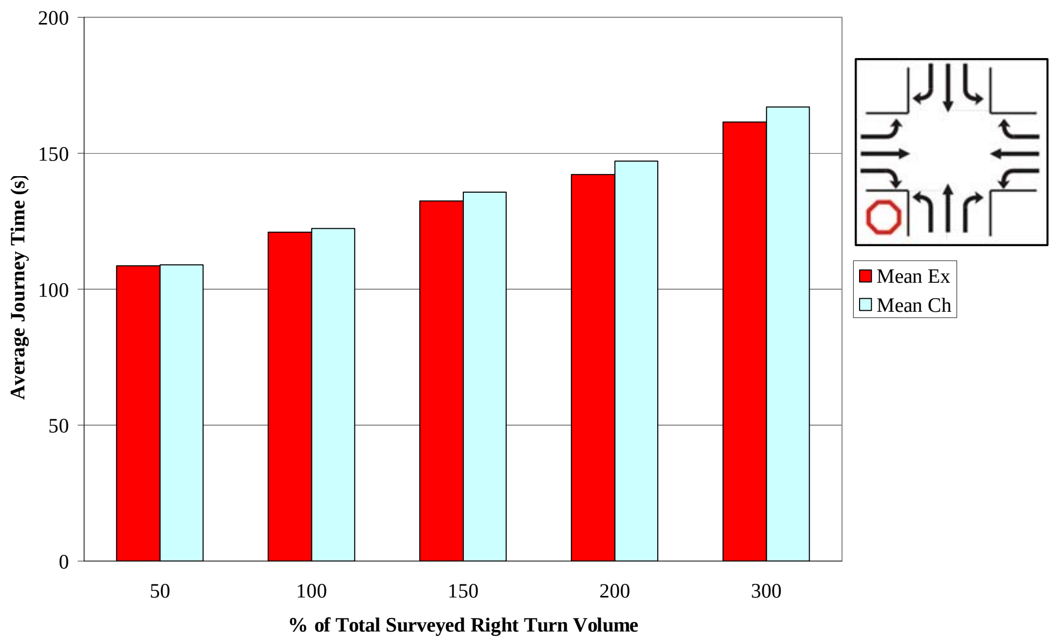

Figure A12.3.12 - Intersection 10, M2, Total Intersection Journey Time Comparison

Table A12.3.2 summarises the average journey times for all movements for each volume scenario.

Table A12.3.2 - Intersection 10, M2, Average Journey Time Comparison

Approach	Mvt	Average Journey Time (seconds/vehicle) for Various % Scenarios									
		50%		100%		150%		200%		300%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Halswell Junction Rd (North)	L	215	227	282	273	327	339	388	417	544	588
	T	265	276	359	340	412	418	488	535	668	722
	R	274	286	375	354	408	432	492	534	672	726
Main South Road (East)	L	84	80	85	80	86	80	86	80	86	80
	T	81	81	81	81	81	81	81	81	81	81
	R	90	92	91	91	91	92	91	92	92	92
Halswell Junction Rd (South)	L	222	218	232	273	337	407	348	349	428	414
	T	326	326	370	401	554	647	532	523	689	635
	R	346	348	373	399	586	695	522	537	691	593
Main South Road (West)	L	33	28	34	28	34	28	35	28	36	28
	T	29	29	29	29	29	29	29	29	29	30
	R	38	39	38	39	39	40	40	42	44	48
Total	All	109	109	121	122	132	136	142	147	161	167

Table A12.3.3 presents a summary of the increase or decrease in journey time the right and left turn movements off Main South Road as a result of the rule change to nearside priority.

Table A12.3.3 - Intersection 10, M2, Right and Left Turn Average Journey Time Changes

Movement	Change in Average Journey Time (seconds/vehicle) for Various % Scenarios				
	75%	100%	125%	150%	175%
Main South Road (East) R	1.1	0.3	0.5	1.1	0.6
Main South Road (West) L	-4.9	-5.7	-6.0	-6.7	-7.4
Main South Road (West) R	0.8	0.9	1.4	1.5	4.3
Main South Road (East) L	-4.4	-5.4	-6.3	-6.0	-6.3

Table A12.3.3 illustrates that there is a consistent pattern through all the tested scenarios of the right turn journey time increasing by around 1 to 2 seconds and the left turn journey time decreasing by 4 to 6 seconds.

Overall the intersection operates slightly more efficiently under the existing rule than it would under the changed rule.

A12.3.3 Queue Lengths Method 1

Figure A12.3.13 to Figure A12.3.18 present queue length comparisons for right and left turns off the major road, Main South Road and also for the longest queue in any lane of the Halswell Junction Road north and south approaches.

It is noted that where a maximum queue length bar does not appear on the graph this is due to the maximum and average queue length being equal which can occur at low values.

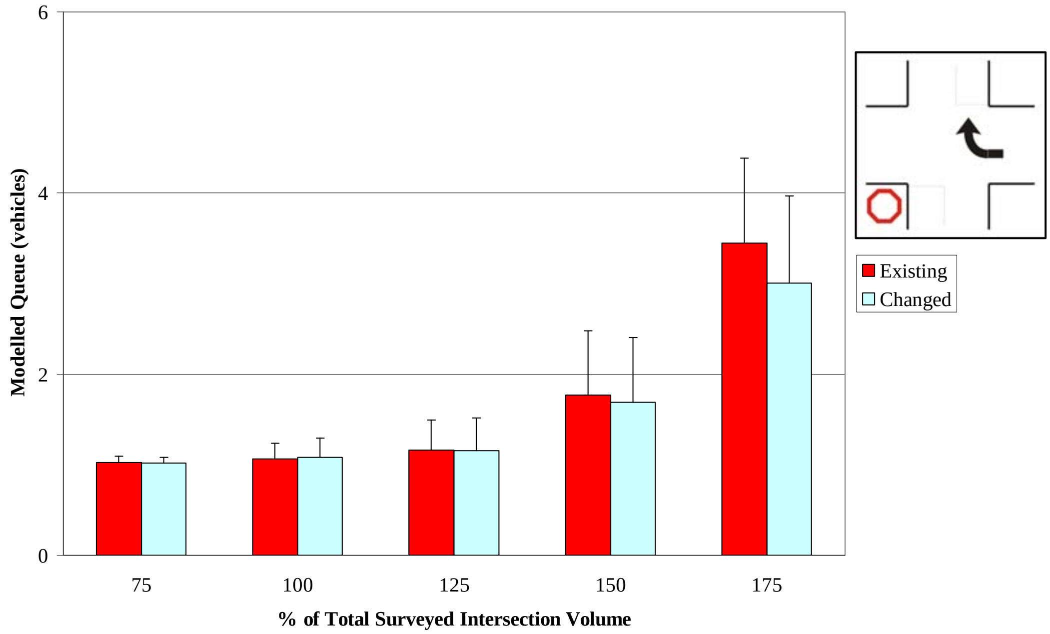

Figure A12.3.13 - Intersection 10, M1, Major Road (East) Right Turn Queue Comparison

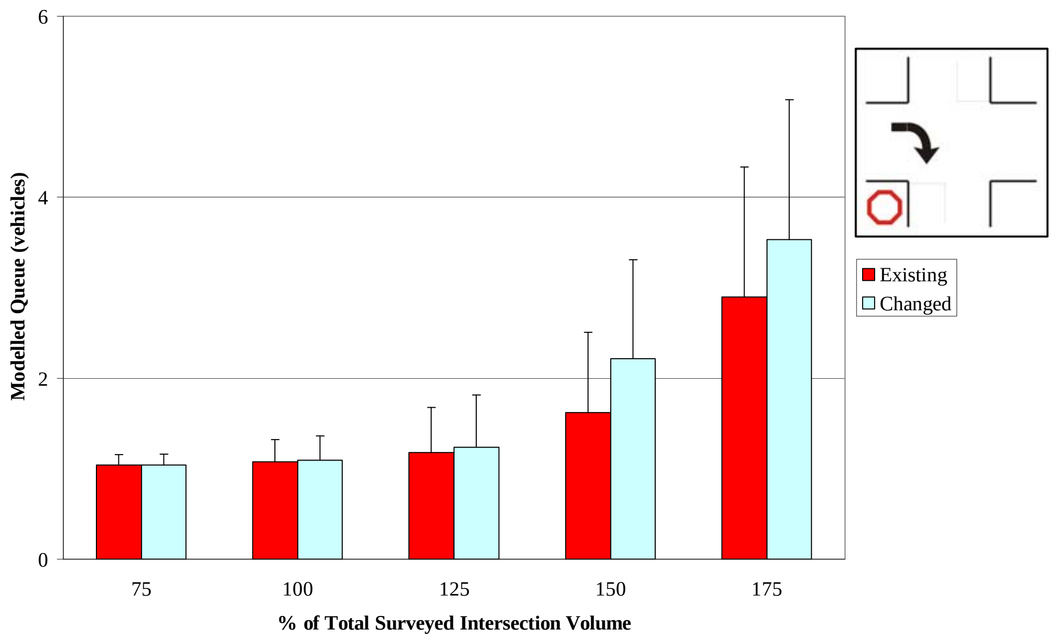

Figure A12.3.14 - Intersection 10, M1, Major Road (West) Right Turn Queue Comparison

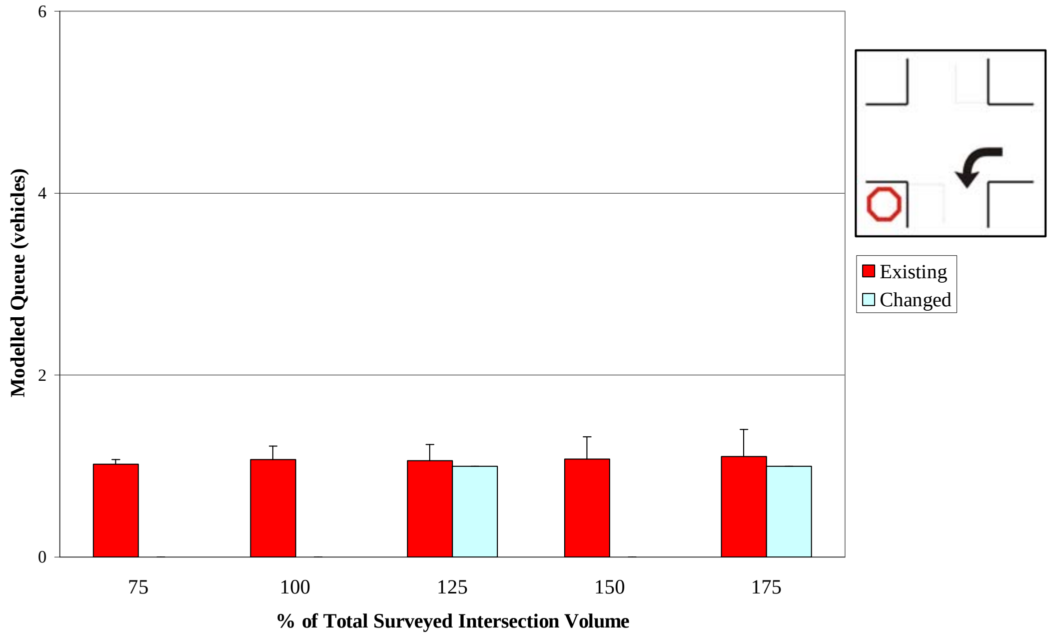

Figure A12.3.15 - Intersection 10, M1, Major Road (East) Left Turn Queue Comparison

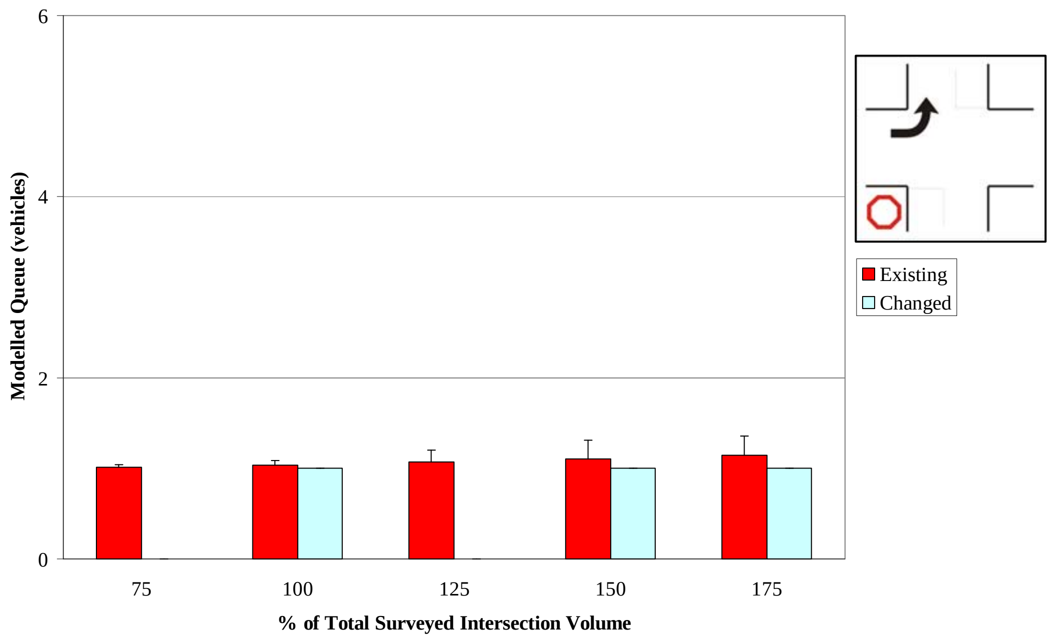

Figure A12.3.16 - Intersection 10, M1, Major Road (West) Left Turn Queue Comparison

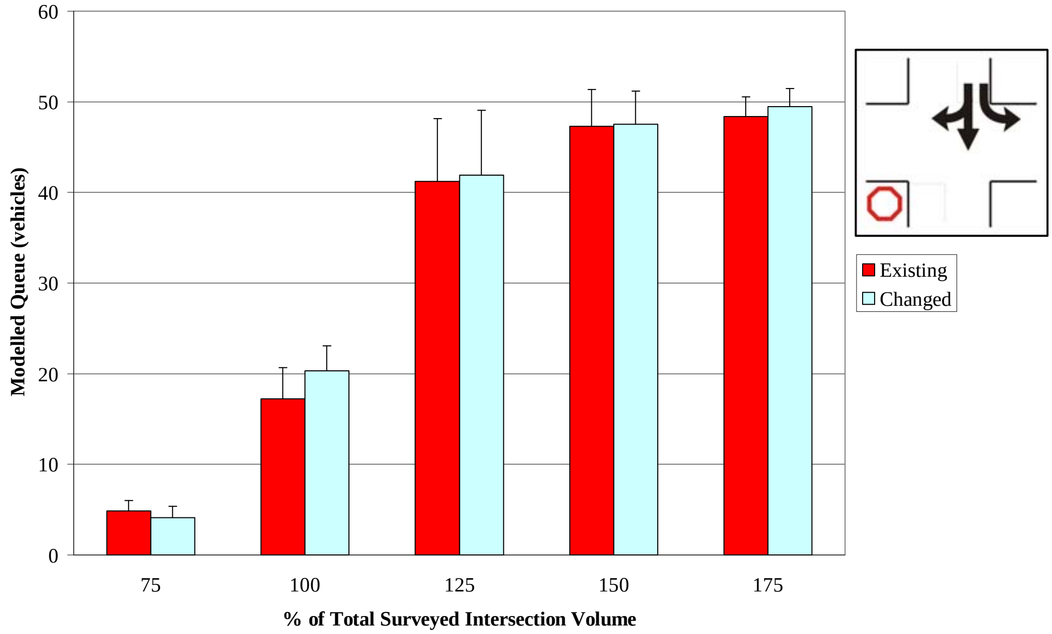

Figure A12.3.17 - Intersection 10, M1, Minor Road (North) Queue Comparison

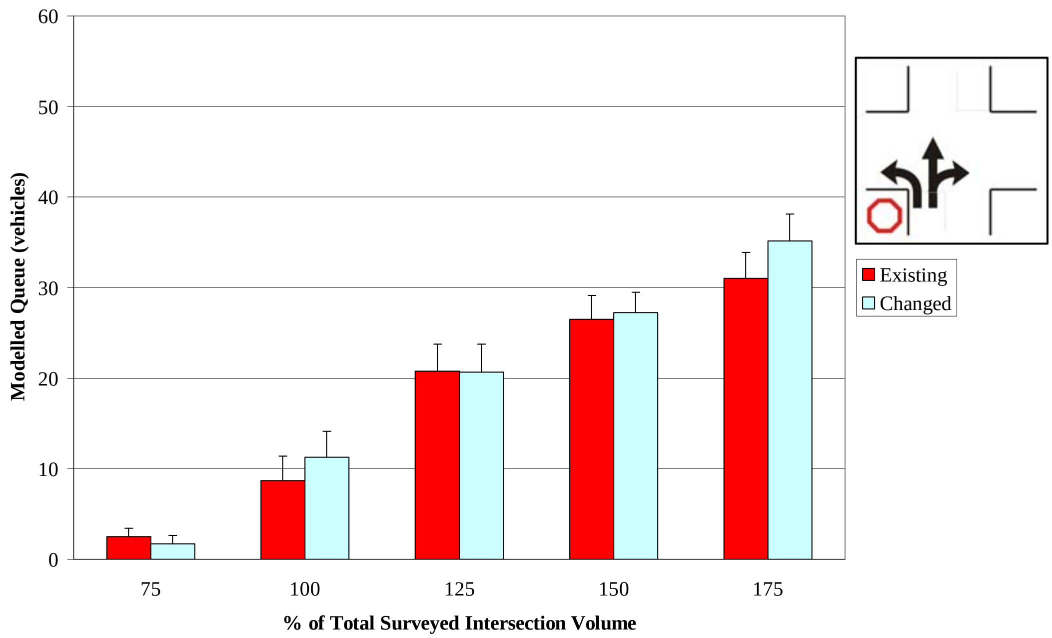

Figure A12.3.18 - Intersection 10, M1, Minor Road (South) Queue Comparison

A12.3.4 Queue Lengths Method 2

Figure A12.3.19 to Figure A12.3.24 present queue length comparisons for right and left turns off the major road, Main South Road and also for the longest queue in any lane of the Halswell Junction Road north and south approaches.

It is noted that where a maximum queue length bar does not appear on the graph this is due to the maximum and average queue length being equal which can occur at low values.

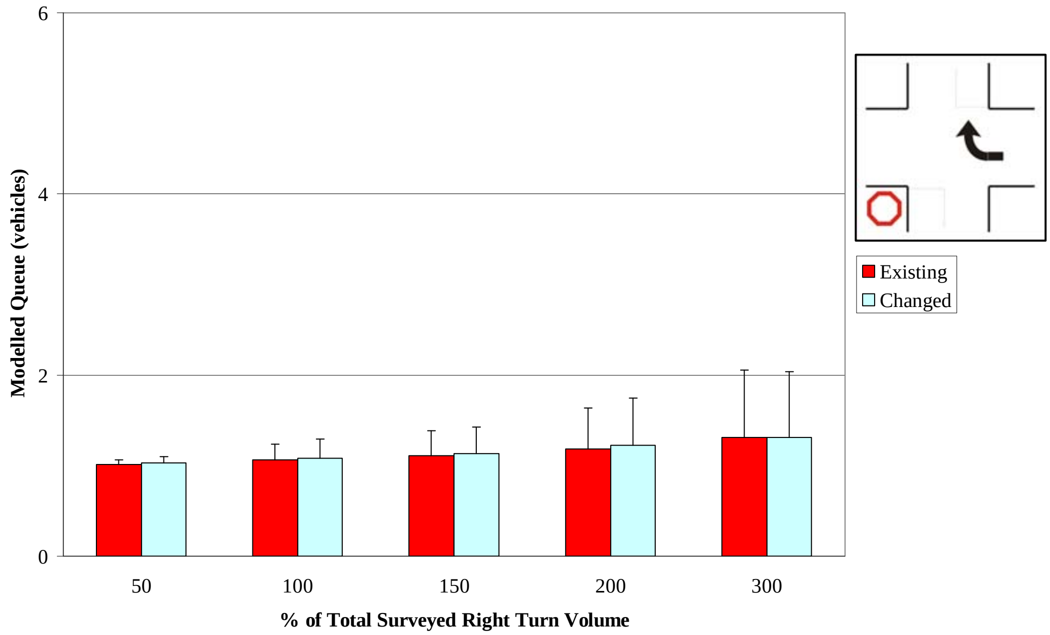

Figure A12.3.19 - Intersection 10, M2, Major Road (East) Right Turn Queue Comparison

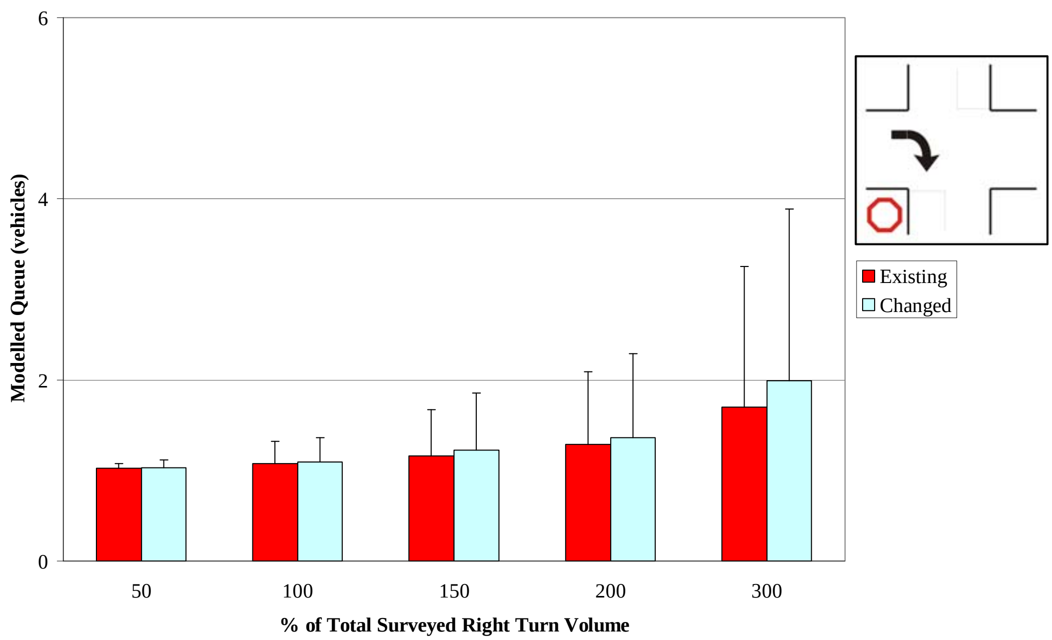

Figure A12.3.20 - Intersection 10, M2, Major Road (West) Right Turn Queue Comparison

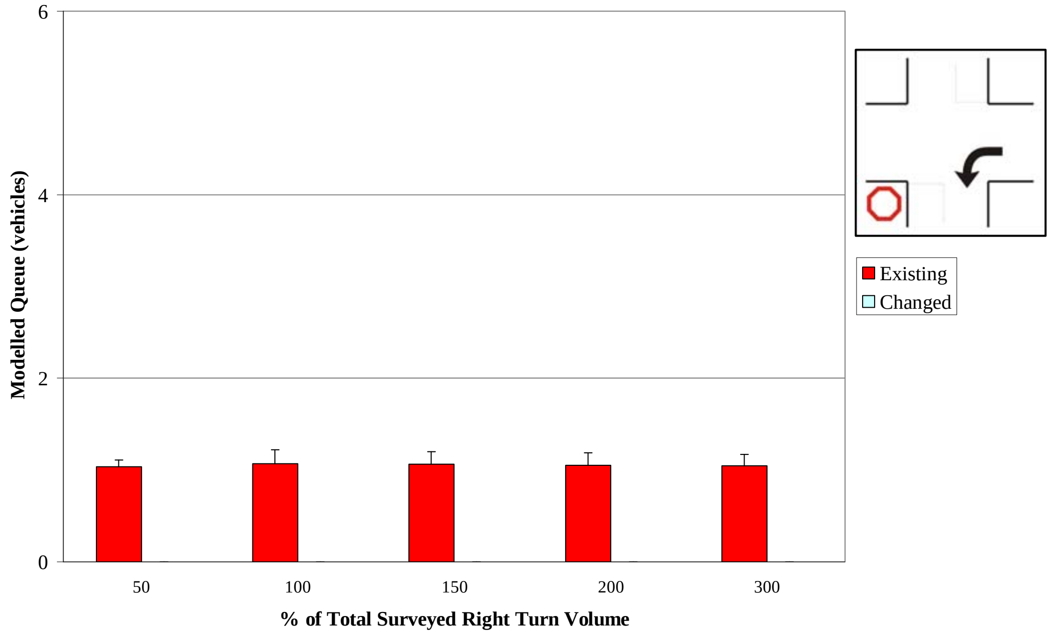

Figure A12.3.21 - Intersection 10, M2, Major Road (East) Left Turn Queue Comparison

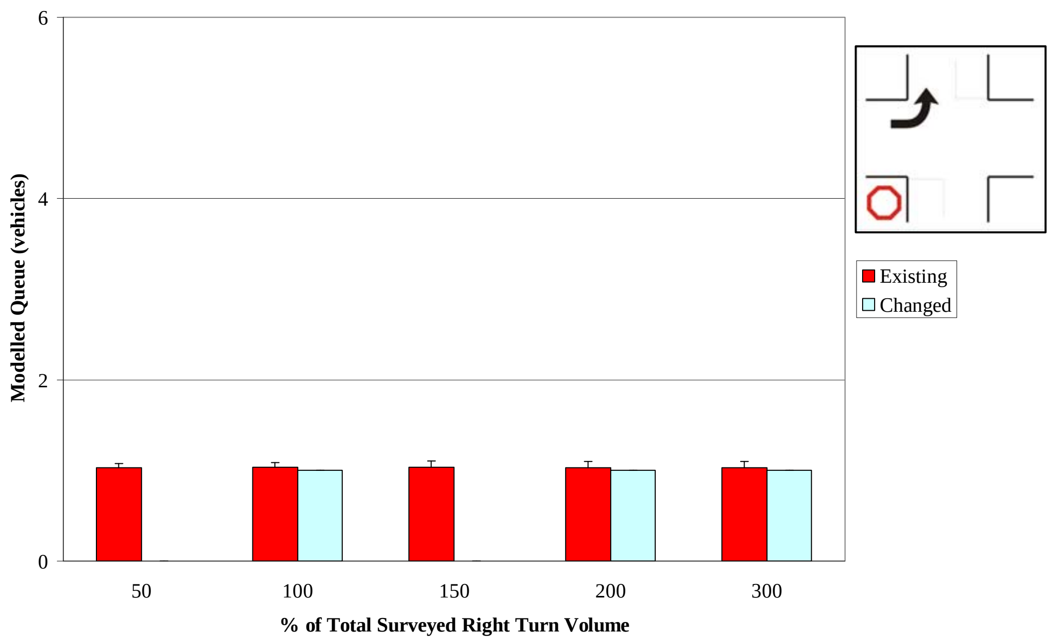

Figure A12.3.22 - Intersection 10, M2, Major Road (West) Left Turn Queue Comparison

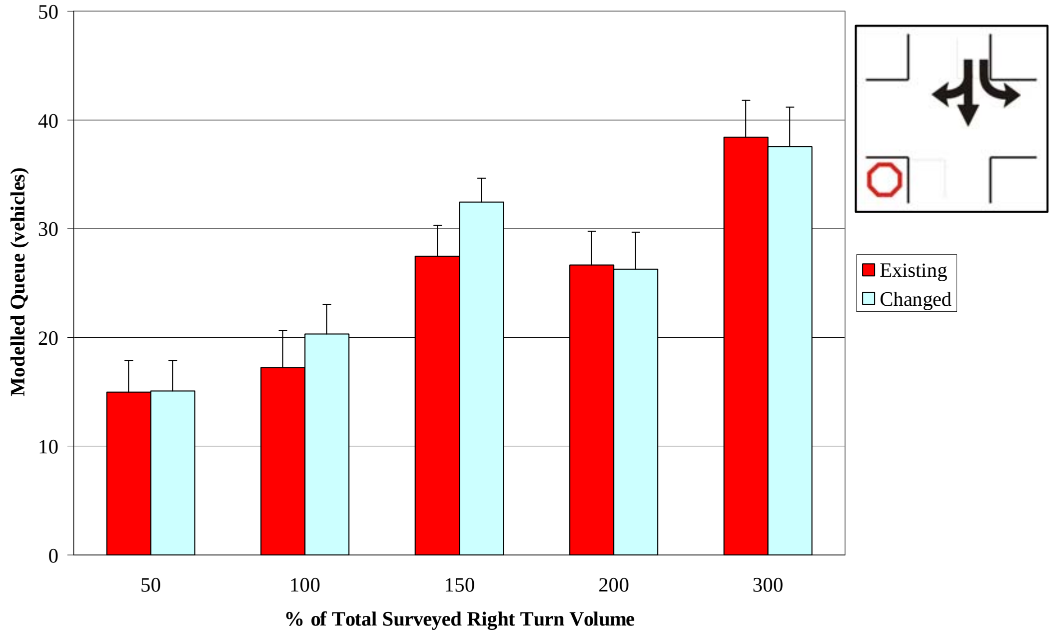

Figure A12.3.23 - Intersection 10, M2, Minor Road (North) Queue Comparison

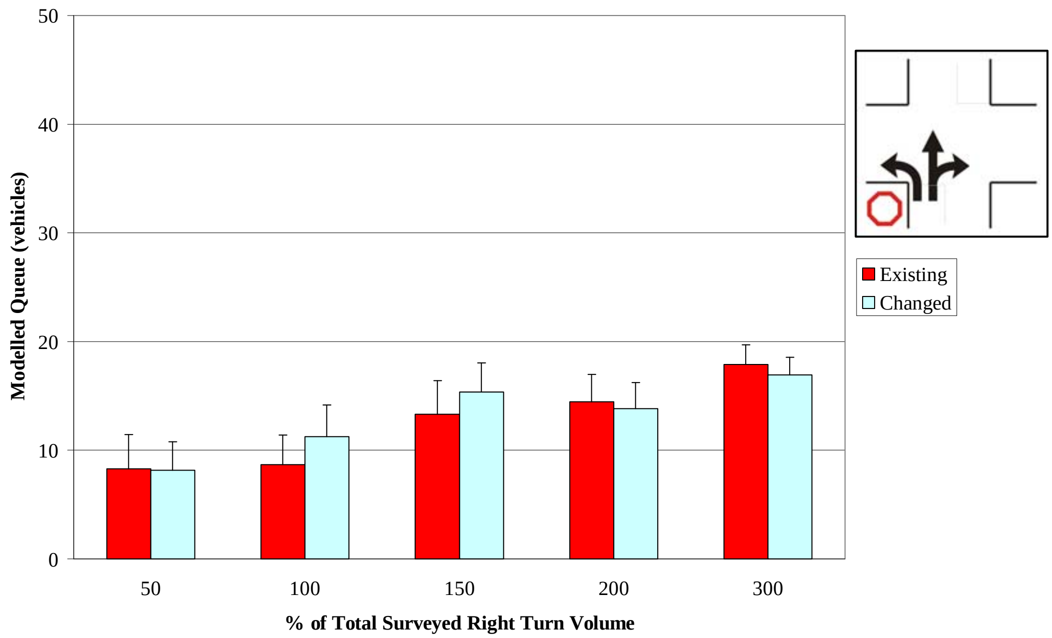

Figure A12.3.24 - Intersection 10, M2, Minor Road (South) Queue Comparison

Table A12.3.4 summarises the average queue lengths for all movements for each volume scenario.

Table A12.3.4 - Intersection 10, M2, Average Queue Comparison

Approach	Mvt	Average Queue Length (vehicles) for Various % Scenarios									
		50%		100%		150%		200%		300%	
		Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch	Ex	Ch
Halswell Junction Road (North)	L	15.0	15.1	17.2	20.3	27.5	32.5	26.6	26.3	38.4	37.5
	TR	3.3	3.3	3.9	4.0	4.3	4.3	4.9	4.6	5.3	5.4
Main South Road (East)	L	1.0	0.0	1.1	0.0	1.1	0.0	1.1	0.0	1.0	0.0
	T	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0
	R	1.0	1.0	1.1	1.1	1.1	1.1	1.2	1.2	1.3	1.3
Halswell Junction Road (South)	L	8.3	8.2	8.7	11.3	13.3	15.3	14.4	13.8	17.9	16.9
	TR	2.7	2.7	3.0	3.0	3.7	4.2	3.4	3.8	4.1	3.6
Main South Road (West)	L	1.0	0.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0
	T	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	R	1.0	1.0	1.1	1.1	1.2	1.2	1.3	1.4	1.7	2.0

The analysis shows that the queue lengths at the intersection are not overly sensitive to the proportion of right turning vehicles. There are some small differences shown between the two rules where the changed rule increases the right turn queue length and removes left turn queue.

A12.4 Full Journey Time Analysis Results

Method 1 Existing Rule							
Mean Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Halswell Junction Rd (North)	L	114.3	282.1	461.0	514.9	291.4
NT		T	156.6	358.6	563.5	580.1	296.6
NR		R	163.9	374.7	547.5	609.1	287.1
EL	Main South Road (East)	L	84.3	85.4	85.9	86.0	113.9
ET		T	80.6	80.8	80.9	81.1	109.1
ER		R	88.1	91.1	96.0	118.2	199.2
SL	Halswell Junction Rd (South)	L	99.3	231.6	356.5	412.1	327.8
ST		T	153.6	369.8	545.3	654.1	531.9
SR		R	169.7	372.9	559.2	640.5	513.7
WL	Main South Road (West)	L	32.9	33.7	34.8	35.7	42.8
WT		T	29.4	29.4	29.5	29.6	35.8
WR		R	36.4	38.3	41.9	51.2	96.1
All Movements		All	73.9	121.1	154.7	153.5	145.1
Median Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Halswell Junction Rd (North)	L	47.0	86.0	108.0	103.0	99.0
NT		T	67.0	102.0	111.0	103.0	97.0
NR		R	74.0	109.0	117.0	108.0	103.0
EL	Main South Road (East)	L	84.0	84.0	84.0	85.0	86.0
ET		T	80.0	81.0	81.0	81.0	82.0
ER		R	86.0	89.0	91.0	98.0	112.0
SL	Halswell Junction Rd (South)	L	37.0	98.0	106.0	104.0	106.0
ST		T	56.0	157.0	108.0	102.0	101.0
SR		R	65.0	163.0	114.0	110.0	107.0
WL	Main South Road (West)	L	31.0	32.0	32.0	32.0	32.0
WT		T	29.0	29.0	29.0	29.0	30.0
WR		R	35.0	36.0	38.0	42.0	51.0
All Movements		All	43.0	77.0	80.0	80.0	81.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Halswell Junction Rd (North)	L	38.0	43.0	87.0	89.0	85.0
NT		T	40.0	59.0	86.0	87.0	82.3
NR		R	45.0	65.0	93.0	91.7	89.0
EL	Main South Road (East)	L	82.0	82.0	82.0	82.0	83.0
ET		T	79.0	79.0	79.0	79.0	80.0
ER		R	83.0	84.0	84.0	86.0	87.0
SL	Halswell Junction Rd (South)	L	30.0	33.0	39.0	47.0	93.0
ST		T	30.0	45.0	82.0	86.0	89.0
SR		R	35.0	55.0	88.0	93.0	94.0
WL	Main South Road (West)	L	31.0	31.0	31.0	31.0	31.0
WT		T	29.0	29.0	29.0	29.0	29.0
WR		R	33.0	33.0	34.0	34.0	35.0
All Movements		All	29.0	29.0	29.0	29.0	30.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Halswell Junction Rd (North)	L	230.5	620.5	783.8	798.3	115.0
NT		T	339.8	945.8	1132.3	1203.8	115.0
NR		R	342.1	933.1	1096.5	1443.3	122.0
EL	Main South Road (East)	L	87.0	89.0	89.0	89.0	112.0
ET		T	82.0	82.0	83.0	83.0	91.0
ER		R	93.0	99.0	108.0	153.0	341.1
SL	Halswell Junction Rd (South)	L	79.0	558.4	751.9	534.8	147.0
ST		T	199.0	896.2	1777.6	2346.2	588.4
SR		R	210.8	933.8	1831.6	2041.2	611.6
WL	Main South Road (West)	L	34.0	35.0	37.0	42.0	57.0
WT		T	30.0	30.0	30.0	30.0	34.0
WR		R	40.0	44.0	51.0	71.0	193.0
All Movements		All	83.0	97.0	104.0	100.0	112.0

Method 1 Changed Rule							
Mean Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Halswell Junction Rd (North)	L	122.9	273.5	458.7	422.5	315.3
NT		T	167.1	340.2	553.8	488.7	326.1
NR		R	173.5	354.3	560.3	540.5	320.7
EL	Main South Road (East)	L	79.8	80.0	80.1	80.4	104.7
ET		T	80.5	80.7	80.7	80.9	104.9
ER		R	88.4	91.4	96.8	115.1	185.8
SL	Halswell Junction Rd (South)	L	81.8	273.4	347.3	380.7	379.0
ST		T	150.3	401.1	554.6	581.8	546.8
SR		R	153.5	398.8	551.1	584.3	532.2
WL	Main South Road (West)	L	28.1	28.1	28.1	28.8	37.4
WT		T	29.4	29.4	29.4	30.1	38.9
WR		R	36.9	39.2	43.5	67.7	110.6
All Movements		All	73.3	122.3	153.3	148.0	148.1
Median Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Halswell Junction Rd (North)	L	48.0	86.0	107.0	102.0	100.0
NT		T	70.0	100.0	107.0	100.0	100.0
NR		R	74.0	108.0	115.0	107.0	107.0
EL	Main South Road (East)	L	80.0	80.0	80.0	80.0	81.0
ET		T	80.0	81.0	81.0	81.0	81.0
ER		R	87.0	89.0	92.0	98.0	106.0
SL	Halswell Junction Rd (South)	L	37.0	104.0	103.0	104.0	107.0
ST		T	61.0	143.0	104.0	101.0	101.0
SR		R	66.0	133.0	109.0	107.0	107.0
WL	Main South Road (West)	L	28.0	28.0	28.0	28.0	28.0
WT		T	29.0	29.0	29.0	29.0	30.0
WR		R	35.0	37.0	39.0	46.0	53.0
All Movements		All	43.0	77.0	79.0	80.0	81.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Halswell Junction Rd (North)	L	38.0	44.0	89.0	87.0	87.0
NT		T	41.0	62.0	90.0	86.0	85.0
NR		R	46.0	69.2	96.0	91.0	92.0
EL	Main South Road (East)	L	78.0	78.0	79.0	79.0	79.0
ET		T	79.0	79.0	79.0	79.0	80.0
ER		R	83.0	84.0	84.0	86.0	87.0
SL	Halswell Junction Rd (South)	L	30.0	33.0	39.0	48.0	94.0
ST		T	30.0	44.0	77.0	87.0	89.2
SR		R	37.0	53.0	82.4	92.0	96.0
WL	Main South Road (West)	L	27.0	27.0	27.0	27.0	27.0
WT		T	29.0	29.0	29.0	29.0	29.0
WR		R	33.0	33.0	34.0	35.0	36.0
All Movements		All	29.0	29.0	29.0	29.0	29.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**75**	**100**	**125**	**150**	**175**
NL	Halswell Junction Rd (North)	L	300.6	587.0	730.1	206.2	116.0
NT		T	403.4	762.0	1140.0	319.8	117.0
NR		R	403.4	787.8	1107.5	457.0	124.0
EL	Main South Road (East)	L	81.0	82.0	82.0	82.0	84.0
ET		T	82.0	82.0	82.0	83.0	84.0
ER		R	94.0	99.0	110.0	150.9	283.7
SL	Halswell Junction Rd (South)	L	77.0	630.0	620.2	330.3	267.5
ST		T	198.3	1014.6	1643.3	1435.0	834.0
SR		R	202.6	970.0	1596.6	1520.2	672.7
WL	Main South Road (West)	L	29.0	29.0	29.0	29.0	35.0
WT		T	30.0	30.0	30.0	30.0	37.0
WR		R	41.0	45.0	54.0	112.0	218.5
All Movements		All	82.0	96.0	102.0	102.0	112.0

Method 2 Existing Rule							
Mean Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Halswell Junction Rd (North)	L	215.2	282.1	327.0	388.1	544.4
NT		T	265.2	358.6	412.4	487.8	667.7
NR		R	274.2	374.7	408.2	491.6	672.2
EL	Main South Road (East)	L	84.4	85.4	86.2	86.0	86.3
ET		T	80.9	80.8	80.8	80.7	80.7
ER		R	90.5	91.1	91.1	91.1	91.6
SL	Halswell Junction Rd (South)	L	221.7	231.6	337.4	348.0	427.8
ST		T	326.1	369.8	554.3	532.0	689.3
SR		R	346.0	372.9	586.0	522.1	691.2
WL	Main South Road (West)	L	33.0	33.7	34.1	34.8	35.8
WT		T	29.5	29.4	29.4	29.4	29.4
WR		R	37.7	38.3	38.9	40.2	43.8
All Movements		All	108.7	121.1	132.5	142.1	161.5
Median Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Halswell Junction Rd (North)	L	80.0	86.0	93.0	102.0	104.0
NT		T	94.0	102.0	106.0	123.0	107.0
NR		R	101.0	109.0	114.0	133.0	113.0
EL	Main South Road (East)	L	84.0	84.0	85.0	85.0	85.0
ET		T	81.0	81.0	81.0	81.0	81.0
ER		R	88.0	89.0	88.0	89.0	89.0
SL	Halswell Junction Rd (South)	L	100.0	98.0	103.0	106.0	103.0
ST		T	154.0	157.0	191.0	127.0	106.0
SR		R	165.0	163.0	190.0	133.0	111.0
WL	Main South Road (West)	L	31.0	32.0	32.0	32.0	32.0
WT		T	29.0	29.0	29.0	29.0	29.0
WR		R	36.0	36.0	37.0	38.0	39.0
All Movements		All	71.0	77.0	78.0	79.0	79.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Halswell Junction Rd (North)	L	43.0	43.0	46.0	50.0	82.0
NT		T	49.0	59.0	70.0	85.0	88.0
NR		R	55.0	65.0	77.0	90.0	92.0
EL	Main South Road (East)	L	82.0	82.0	82.0	82.0	82.0
ET		T	79.0	79.0	79.0	79.0	79.0
ER		R	84.0	84.0	84.0	84.0	84.0
SL	Halswell Junction Rd (South)	L	33.0	33.0	33.0	33.0	33.0
ST		T	40.0	45.0	55.0	77.1	83.0
SR		R	44.0	55.0	68.0	74.1	90.0
WL	Main South Road (West)	L	31.0	31.0	31.0	31.0	31.0
WT		T	29.0	29.0	29.0	29.0	29.0
WR		R	33.0	33.0	34.0	34.0	34.0
All Movements		All	29.0	29.0	29.0	29.0	29.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Halswell Junction Rd (North)	L	483.8	620.5	607.2	599.3	794.7
NT		T	607.4	945.8	909.6	987.8	2219.0
NR		R	624.9	933.1	854.4	973.5	2163.9
EL	Main South Road (East)	L	87.0	89.0	90.0	90.0	90.0
ET		T	82.0	82.0	82.0	82.0	82.0
ER		R	98.0	99.0	98.0	99.0	100.0
SL	Halswell Junction Rd (South)	L	402.0	558.4	806.4	868.2	1561.8
ST		T	665.0	896.2	1201.6	1658.8	2183.2
SR		R	651.1	933.8	1222.7	1607.4	2088.4
WL	Main South Road (West)	L	34.0	35.0	37.0	38.0	39.0
WT		T	30.0	30.0	30.0	30.0	30.0
WR		R	43.0	44.0	45.0	47.0	54.0
All Movements		All	92.0	97.0	96.0	102.0	99.0

Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Halswell Junction Rd (North)	L	226.5	273.5	339.1	416.9	588.5
NT		T	276.4	340.2	418.0	535.1	721.6
NR		R	285.8	354.3	432.5	534.3	726.4
EL	Main South Road (East)	L	79.9	80.0	79.9	80.0	80.0
ET		T	80.7	80.7	80.6	80.5	80.6
ER		R	91.5	91.4	91.5	92.2	92.2
SL	Halswell Junction Rd (South)	L	217.9	273.4	406.8	349.1	413.9
ST		T	326.0	401.1	646.9	523.3	634.9
SR		R	348.0	398.8	695.4	537.2	592.9
WL	Main South Road (West)	L	28.1	28.1	28.1	28.2	28.4
WT		T	29.4	29.4	29.3	29.3	29.6
WR		R	38.5	39.2	40.3	41.7	48.1
All Movements		All	108.9	122.3	135.6	147.1	167.0
Median Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Halswell Junction Rd (North)	L	73.0	86.0	93.0	106.0	105.0
NT		T	94.0	100.0	111.0	143.0	112.0
NR		R	98.0	108.0	118.0	138.0	117.0
EL	Main South Road (East)	L	80.0	80.0	80.0	80.0	80.0
ET		T	81.0	81.0	80.0	80.0	80.0
ER		R	89.0	89.0	88.0	89.0	89.0
SL	Halswell Junction Rd (South)	L	84.0	104.0	107.0	104.0	104.0
ST		T	150.0	143.0	232.0	122.0	107.0
SR		R	162.0	133.0	244.0	131.0	111.0
WL	Main South Road (West)	L	28.0	28.0	28.0	28.0	28.0
WT		T	29.0	29.0	29.0	29.0	29.0
WR		R	37.0	37.0	37.0	38.0	41.0
All Movements		All	66.0	77.0	77.0	78.0	79.0
15-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Halswell Junction Rd (North)	L	43.0	44.0	45.0	55.0	82.0
NT		T	49.0	62.0	75.0	87.0	87.0
NR		R	55.0	69.2	80.8	91.0	93.0
EL	Main South Road (East)	L	78.0	78.0	78.0	78.0	78.0
ET		T	79.0	79.0	79.0	79.0	79.0
ER		R	84.0	84.0	84.0	84.0	84.0
SL	Halswell Junction Rd (South)	L	33.0	33.0	33.0	33.0	32.0
ST		T	39.0	44.0	62.0	68.3	83.0
SR		R	43.8	53.0	68.0	70.2	90.1
WL	Main South Road (West)	L	27.0	27.0	27.0	27.0	27.0
WT		T	29.0	29.0	29.0	29.0	29.0
WR		R	33.0	33.0	34.0	34.0	34.0
All Movements		All	29.0	29.0	29.0	29.0	29.0
85-Percentile Travel Time (seconds)							
Movement	Approach		**50**	**100**	**150**	**200**	**300**
NL	Halswell Junction Rd (North)	L	517.2	587.0	625.0	744.4	1207.5
NT		T	641.8	762.0	900.3	1502.3	2529.0
NR		R	675.9	787.8	1067.0	1305.0	2591.8
EL	Main South Road (East)	L	81.0	82.0	82.0	82.0	82.0
ET		T	82.0	82.0	82.0	82.0	82.0
ER		R	99.0	99.0	99.0	100.0	101.0
SL	Halswell Junction Rd (South)	L	411.4	630.0	956.3	861.6	1366.3
ST		T	648.6	1014.6	1444.8	1569.0	2093.8
SR		R	682.8	970.0	1481.3	1704.4	2062.5
WL	Main South Road (West)	L	29.0	29.0	29.0	29.0	29.0
WT		T	30.0	30.0	30.0	30.0	30.0
WR		R	44.0	45.0	47.0	51.0	65.0
All Movements		All	90.0	96.0	94.0	103.0	101.0

A12.5 Full Queue Length Analysis Results

Method 1							
Existing Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Halswell Junction Road (North)	L	4.9	17.2	41.2	47.3	48.4
N2		TR	2.1	3.9	5.3	5.6	5.8
E1	Main South Road (East)	L	1.0	1.1	1.1	1.1	1.1
E2		T	1.0	1.0	1.0	1.0	1.0
E3		R	1.0	1.1	1.2	1.8	3.4
S1	Halswell Junction Road (South)	L	2.5	8.7	20.8	26.5	31.1
S2		TR	1.8	3.0	4.5	5.2	6.0
W1	Main South Road (West)	L	1.0	1.0	1.1	1.1	1.1
W2		T	1.0	1.0	1.0	1.0	1.0
W3		R	1.0	1.1	1.2	1.6	2.9
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Halswell Junction Road (North)	L	6.0	20.7	48.1	51.3	50.5
N2		TR	2.9	5.0	6.0	6.0	6.1
E1	Main South Road (East)	L	1.1	1.2	1.2	1.3	1.4
E2		T	1.0	1.0	1.0	1.0	1.0
E3		R	1.1	1.2	1.5	2.5	4.4
S1	Halswell Junction Road (South)	L	3.4	11.4	23.7	29.1	33.9
S2		TR	2.2	3.5	4.9	5.5	6.3
W1	Main South Road (West)	L	1.0	1.1	1.2	1.3	1.4
W2		T	1.0	1.0	1.0	1.0	1.0
W3		R	1.2	1.3	1.7	2.5	4.3
Changed Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Halswell Junction Road (North)	L	4.1	20.3	41.9	47.5	49.4
N2		TR	2.1	4.0	5.5	5.8	5.5
E1	Main South Road (East)	L	0.0	0.0	1.0	0.0	1.0
E2		T	1.0	1.1	1.0	1.0	1.0
E3		R	1.0	1.1	1.2	1.7	3.0
S1	Halswell Junction Road (South)	L	1.7	11.3	20.7	27.3	35.1
S2		TR	1.6	3.0	4.6	4.4	5.3
W1	Main South Road (West)	L	0.0	1.0	0.0	1.0	1.0
W2		T	1.0	1.0	1.0	1.0	1.1
W3		R	1.0	1.1	1.2	2.2	3.5
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**75**	**100**	**125**	**150**	**175**
N1	Halswell Junction Road (North)	L	5.4	23.1	49.1	51.2	51.5
N2		TR	3.0	5.1	6.2	6.2	5.7
E1	Main South Road (East)	L	0.0	0.0	1.0	0.0	1.0
E2		T	1.0	1.2	1.0	1.0	1.0
E3		R	1.1	1.3	1.5	2.4	4.0
S1	Halswell Junction Road (South)	L	2.6	14.2	23.8	29.5	38.1
S2		TR	2.0	3.5	5.1	4.8	5.6
W1	Main South Road (West)	L	0.0	1.0	0.0	1.0	1.0
W2		T	1.0	1.0	1.0	1.0	1.1
W3		R	1.2	1.4	1.8	3.3	5.1

Method 2							
Existing Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Halswell Junction Road (North)	L	15.0	17.2	27.5	26.6	38.4
N2		TR	3.3	3.9	4.3	4.9	5.3
E1	Main South Road (East)	L	1.0	1.1	1.1	1.1	1.0
E2		T	1.0	1.0	1.0	1.0	1.0
E3		R	1.0	1.1	1.1	1.2	1.3
S1	Halswell Junction Road (South)	L	8.3	8.7	13.3	14.4	17.9
S2		TR	2.7	3.0	3.7	3.4	4.1
W1	Main South Road (West)	L	1.0	1.0	1.0	1.0	1.0
W2		T	1.0	1.0	1.0	1.0	1.0
W3		R	1.0	1.1	1.2	1.3	1.7
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Halswell Junction Road (North)	L	17.9	20.7	30.3	29.8	41.8
N2		TR	4.5	5.0	5.3	5.6	5.8
E1	Main South Road (East)	L	1.1	1.2	1.2	1.2	1.2
E2		T	1.0	1.0	1.0	1.0	1.0
E3		R	1.1	1.2	1.4	1.6	2.1
S1	Halswell Junction Road (South)	L	11.4	11.4	16.4	17.0	19.7
S2		TR	3.2	3.5	4.2	3.9	4.4
W1	Main South Road (West)	L	1.1	1.1	1.1	1.1	1.1
W2		T	1.0	1.0	1.0	1.0	1.0
W3		R	1.1	1.3	1.7	2.1	3.3
Changed Rule							
Average Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Halswell Junction Road (North)	L	15.1	20.3	32.5	26.3	37.5
N2		TR	3.3	4.0	4.3	4.6	5.4
E1	Main South Road (East)	L	0.0	0.0	0.0	0.0	0.0
E2		T	1.0	1.1	1.0	1.0	1.0
E3		R	1.0	1.1	1.1	1.2	1.3
S1	Halswell Junction Road (South)	L	8.2	11.3	15.3	13.8	16.9
S2		TR	2.7	3.0	4.2	3.8	3.6
W1	Main South Road (West)	L	0.0	1.0	0.0	1.0	1.0
W2		T	1.0	1.0	1.0	1.0	1.0
W3		R	1.0	1.1	1.2	1.4	2.0
Maximum Queue Length (vehicles)							
Queue	Approach	Mvt	**50**	**100**	**150**	**200**	**300**
N1	Halswell Junction Road (North)	L	17.9	23.1	34.7	29.7	41.2
N2		TR	4.4	5.1	5.2	5.4	5.8
E1	Main South Road (East)	L	0.0	0.0	0.0	0.0	0.0
E2		T	1.0	1.2	1.0	1.0	1.0
E3		R	1.1	1.3	1.4	1.7	2.0
S1	Halswell Junction Road (South)	L	10.8	14.2	18.0	16.2	18.5
S2		TR	3.3	3.5	4.6	4.2	4.0
W1	Main South Road (West)	L	0.0	1.0	0.0	1.0	1.0
W2		T	1.0	1.0	1.0	1.0	1.0
W3		R	1.1	1.4	1.9	2.3	3.9

APPENDIX A13

AM CBD Network Testing Link Volumes

Notes:

Ex	= Existing Rule (far side priority)
Ch	= Changed Rule (nearside priority)
Diff	= Difference (Existing – Changed)
%	= Percentage Change (Difference/Existing)

Data is presented in order of descending difference

Volume (vph)		Diff (vph)	%
Ex	Ch		
508	593	85	17%
458	524	66	14%
1,700	1,765	65	4%
1,701	1,766	65	4%
416	476	61	15%
651	710	59	9%
1,704	1,762	58	3%
1,705	1,763	58	3%
465	521	57	12%
465	521	57	12%
1,671	1,727	56	3%
657	713	56	8%
657	712	55	8%
2,128	2,182	54	3%
1,683	1,737	54	3%
134	187	52	39%
136	187	51	38%
2,127	2,179	51	2%
136	187	51	38%
1,718	1,769	50	3%
1,718	1,767	50	3%
1,715	1,765	50	3%
520	569	49	9%
1,702	1,749	47	3%
467	514	47	10%
469	515	47	10%
2,124	2,171	46	2%
490	535	45	9%
491	535	45	9%
418	463	45	11%
281	325	45	16%
278	323	45	16%
508	551	44	9%
522	565	43	8%
631	673	42	7%
197	239	42	21%
197	239	42	21%
1,755	1,797	42	2%
537	578	42	8%
632	673	41	7%
633	674	41	6%
1,315	1,355	40	3%
506	546	40	8%
1,719	1,758	39	2%
1,321	1,360	39	3%
1,322	1,360	38	3%
650	689	38	6%
465	503	38	8%
652	690	38	6%

Volume (vph)		Diff (vph)	%
Ex	Ch		
439	477	38	9%
440	478	37	8%
1,680	1,717	37	2%
441	478	37	8%
1,608	1,644	36	2%
1,901	1,937	36	2%
1,080	1,116	36	3%
1,344	1,380	36	3%
1,238	1,274	36	3%
1,038	1,074	36	3%
373	409	36	10%
1,620	1,656	36	2%
1,902	1,938	36	2%
1,342	1,378	36	3%
1,346	1,382	35	3%
1,903	1,939	35	2%
1,682	1,718	35	2%
378	414	35	9%
610	645	35	6%
1,559	1,593	35	2%
1,376	1,410	34	2%
751	785	34	5%
614	648	34	6%
1,366	1,400	34	2%
427	461	34	8%
1,230	1,264	34	3%
1,371	1,405	34	2%
617	651	34	5%
1,047	1,080	33	3%
1,593	1,626	33	2%
1,049	1,082	33	3%
1,350	1,383	33	2%
1,265	1,297	33	3%
1,231	1,264	32	3%
1,371	1,403	32	2%
1,052	1,084	32	3%
1,232	1,264	31	3%
1,091	1,122	31	3%
421	451	31	7%
1,766	1,797	31	2%
1,767	1,798	31	2%
421	451	30	7%
1,767	1,798	30	2%
1,209	1,238	30	2%
198	227	30	15%
1,381	1,411	30	2%
1,214	1,243	29	2%
1,205	1,234	29	2%
1,200	1,229	29	2%

Volume (vph)		Diff (vph)	%
Ex	Ch		
1,808	1,837	29	2%
369	398	29	8%
740	768	28	4%
1,059	1,088	28	3%
166	194	28	17%
1,053	1,081	28	3%
230	258	28	12%
1,053	1,081	28	3%
1,786	1,814	28	2%
1,130	1,158	28	2%
229	257	28	12%
742	770	28	4%
277	305	28	10%
230	257	28	12%
351	378	27	8%
300	327	27	9%
1,216	1,242	27	2%
1,058	1,085	27	3%
1,194	1,221	27	2%
1,825	1,851	26	1%
1,057	1,084	26	2%
48	73	26	54%
860	886	26	3%
1,225	1,250	25	2%
377	402	25	7%
367	392	25	7%
1,160	1,185	25	2%
216	240	25	11%
1,222	1,246	24	2%
445	470	24	5%
569	593	24	4%
524	548	24	5%
1,164	1,188	24	2%
593	617	24	4%
524	547	24	5%
1,222	1,246	24	2%
302	326	24	8%
660	684	24	4%
229	252	24	10%
297	320	24	8%
1,216	1,239	23	2%
1,051	1,075	23	2%
367	390	23	6%
664	687	23	3%
663	686	23	3%
115	138	23	20%
228	251	23	10%
662	685	23	3%
288	311	23	8%

Volume (vph)		Diff (vph)	%
Ex	Ch		
2,016	2,038	22	1%
887	909	22	2%
568	590	22	4%
297	319	22	7%
262	284	22	8%
465	487	22	5%
543	565	22	4%
458	480	22	5%
1,654	1,676	22	1%
543	565	22	4%
297	319	22	7%
2,011	2,032	22	1%
480	502	22	4%
239	260	22	9%
755	776	21	3%
410	432	21	5%
532	553	21	4%
117	138	21	18%
650	671	21	3%
934	955	21	2%
891	912	21	2%
412	433	21	5%
257	278	21	8%
288	309	21	7%
2,003	2,024	21	1%
420	441	21	5%
408	429	21	5%
197	218	21	11%
892	913	21	2%
1,149	1,170	21	2%
892	913	21	2%
442	463	20	5%
174	194	20	12%
935	956	20	2%
534	554	20	4%
420	440	20	5%
436	456	20	5%
483	503	20	4%
2,050	2,070	20	1%
768	787	20	3%
485	505	20	4%
210	230	20	9%
1,740	1,760	20	1%
1,659	1,679	20	1%
530	549	20	4%
485	504	20	4%
984	1,003	20	2%
1,082	1,102	19	2%
566	585	19	3%

Volume (vph)		Diff (vph)	%
Ex	Ch		
475	494	19	4%
569	588	19	3%
475	494	19	4%
479	498	19	4%
523	542	19	4%
653	671	19	3%
279	297	19	7%
1,571	1,589	19	1%
1,088	1,107	19	2%
762	780	19	2%
528	547	19	4%
446	465	19	4%
1,493	1,511	18	1%
762	780	18	2%
761	780	18	2%
450	468	18	4%
513	531	18	4%
1,525	1,543	18	1%
1,577	1,595	18	1%
513	531	18	4%
447	465	18	4%
1,662	1,680	18	1%
896	914	18	2%
638	656	18	3%
327	345	18	5%
1,744	1,761	18	1%
930	948	18	2%
327	344	18	5%
325	342	17	5%
157	174	17	11%
931	947	17	2%
227	243	16	7%
100	116	16	16%
394	411	16	4%
638	654	16	3%
1,435	1,451	16	1%
1,390	1,406	16	1%
684	700	16	2%
325	341	16	5%
55	71	16	29%
1,259	1,275	16	1%
519	535	16	3%
2,053	2,069	16	1%
572	587	16	3%
1,225	1,241	15	1%
573	588	15	3%
1,012	1,027	15	2%
120	136	15	13%
294	309	15	5%

Volume (vph)		Diff (vph)	%
Ex	Ch		
1,580	1,595	15	1%
794	809	15	2%
487	502	15	3%
922	936	15	2%
1,129	1,143	15	1%
572	587	15	3%
880	895	14	2%
880	894	14	2%
679	693	14	2%
486	500	14	3%
324	338	14	4%
561	575	14	2%
561	575	14	2%
1,610	1,623	14	1%
1,017	1,031	14	1%
879	893	14	2%
1,630	1,643	14	1%
292	306	14	5%
184	197	14	7%
109	122	14	13%
1,610	1,624	14	1%
1,527	1,540	14	1%
1,630	1,644	14	1%
576	589	14	2%
778	792	13	2%
481	494	13	3%
200	214	13	7%
1,630	1,644	13	1%
572	585	13	2%
521	534	13	3%
801	815	13	2%
805	818	13	2%
575	588	13	2%
521	534	13	2%
344	357	13	4%
210	223	13	6%
1,930	1,943	13	1%
526	539	13	2%
1,294	1,307	13	1%
789	802	13	2%
1,151	1,164	13	1%
926	939	13	1%
805	818	13	2%
61	74	13	21%
1,584	1,596	13	1%
526	539	13	2%
526	539	13	2%
1,487	1,499	13	1%
296	309	13	4%

Volume (vph)		Diff (vph)	%
Ex	Ch		
212	225	13	6%
1,487	1,499	13	1%
743	755	13	2%
287	299	13	4%
282	294	13	4%
296	308	12	4%
558	571	12	2%
480	492	12	3%
204	217	12	6%
569	581	12	2%
1,388	1,400	12	1%
58	70	12	21%
35	47	12	33%
1,616	1,627	12	1%
1,518	1,530	11	1%
1,127	1,139	11	1%
1,609	1,620	11	1%
1,267	1,278	11	1%
94	105	11	12%
94	105	11	12%
23	34	11	49%
564	575	11	2%
525	536	11	2%
193	204	11	6%
24	35	11	46%
1,414	1,425	11	1%
1,124	1,135	11	1%
940	951	11	1%
1,684	1,695	11	1%
1,591	1,602	11	1%
1,490	1,501	11	1%
21	31	11	52%
212	223	11	5%
15	26	11	71%
503	514	11	2%
455	465	11	2%
457	468	10	2%
213	223	10	5%
149	159	10	7%
940	951	10	1%
562	573	10	2%
504	514	10	2%
666	676	10	2%
563	573	10	2%
69	79	10	15%
1,574	1,584	10	1%
1,977	1,987	10	1%
363	373	10	3%
13	23	10	78%

Volume (vph)		Diff (vph)	%
Ex	Ch		
128	138	10	8%
1,027	1,037	10	1%
434	444	10	2%
172	181	10	6%
157	167	10	6%
71	81	10	14%
47	57	10	21%
1,213	1,223	10	1%
71	81	10	14%
1,582	1,591	10	1%
82	92	10	12%
8	18	10	122%
1,347	1,357	10	1%
1,095	1,104	10	1%
8	18	10	119%
8	18	10	119%
8	18	10	119%
1,463	1,472	9	1%
199	209	9	5%
83	93	9	11%
126	135	9	7%
432	441	9	2%
1,972	1,981	9	0%
235	244	9	4%
231	241	9	4%
936	945	9	1%
1,567	1,576	9	1%
8	17	9	116%
1,028	1,037	9	1%
231	240	9	4%
47	56	9	20%
13	22	9	73%
923	932	9	1%
619	628	9	1%
430	439	9	2%
46	55	9	19%
391	400	9	2%
184	193	9	5%
129	138	9	7%
107	115	9	8%
137	146	9	6%
1,252	1,261	9	1%
160	169	9	5%
239	248	9	4%
239	248	9	4%
1,160	1,169	9	1%
8	16	9	115%
7	15	9	130%
81	90	9	11%

Volume (vph)		Diff (vph)	%
Ex	Ch		
1,240	1,249	9	1%
1,154	1,163	9	1%
210	218	9	4%
186	194	9	5%
186	194	9	5%
156	165	9	5%
1,153	1,162	8	1%
607	615	8	1%
167	175	8	5%
7	16	8	118%
623	632	8	1%
530	539	8	2%
432	440	8	2%
137	146	8	6%
773	781	8	1%
123	132	8	7%
17	25	8	49%
138	146	8	6%
1,272	1,280	8	1%
23	31	8	36%
5	13	8	156%
239	247	8	3%
298	306	8	3%
225	233	8	4%
225	233	8	4%
373	381	8	2%
2,022	2,030	8	0%
64	71	8	12%
164	171	8	5%
129	136	8	6%
915	922	8	1%
83	91	8	9%
81	89	8	9%
58	66	8	13%
51	58	8	15%
369	376	8	2%
180	187	8	4%
35	42	8	22%
1,577	1,584	7	0%
917	925	7	1%
1,848	1,856	7	0%
46	54	7	16%
34	42	7	21%
464	471	7	2%
369	376	7	2%
540	547	7	1%
353	360	7	2%
62	69	7	11%
425	432	7	2%

Volume (vph)		Diff (vph)	%
Ex	Ch		
352	359	7	2%
466	473	7	2%
61	68	7	12%
207	214	7	3%
1,379	1,386	7	0%
201	207	7	3%
1,387	1,393	7	0%
370	377	7	2%
22	29	7	29%
18	25	7	35%
789	795	6	1%
366	373	6	2%
67	73	6	10%
48	55	6	13%
18	25	6	35%
10	17	6	62%
104	110	6	6%
1,020	1,026	6	1%
562	569	6	1%
43	49	6	15%
1,167	1,173	6	1%
896	902	6	1%
564	570	6	1%
454	461	6	1%
397	403	6	2%
36	42	6	17%
36	42	6	17%
426	432	6	1%
789	795	6	1%
1,396	1,402	6	0%
991	997	6	1%
404	410	6	2%
371	377	6	2%
1,220	1,226	6	1%
1,357	1,363	6	0%
371	377	6	2%
371	377	6	2%
48	54	6	12%
877	883	6	1%
252	258	6	2%
1,388	1,394	6	0%
470	476	6	1%
368	374	6	2%
235	241	6	2%
88	94	6	7%
599	605	6	1%
371	377	6	2%
371	377	6	2%
156	161	6	4%

Volume (vph)		Diff (vph)	%
Ex	Ch		
85	91	6	7%
563	569	6	1%
274	279	6	2%
133	139	6	4%
95	101	6	6%
1,929	1,935	6	0%
1,327	1,332	6	0%
1,230	1,235	6	0%
1,223	1,228	6	0%
623	628	6	1%
263	269	6	2%
217	223	6	3%
159	164	6	3%
155	161	6	4%
122	128	6	5%
6	12	6	89%
2	7	6	367%
1	7	6	393%
122	128	5	4%
416	422	5	1%
363	369	5	1%
88	93	5	6%
1	7	5	379%
1	7	5	379%
1	7	5	379%
1,363	1,368	5	0%
1,260	1,265	5	0%
875	880	5	1%
212	217	5	2%
158	164	5	3%
130	135	5	4%
634	639	5	1%
241	246	5	2%
235	240	5	2%
157	162	5	3%
1,259	1,264	5	0%
1,355	1,360	5	0%
1,025	1,030	5	0%
553	558	5	1%
501	506	5	1%
417	422	5	1%
343	348	5	1%
84	89	5	6%
49	54	5	10%
221	226	5	2%
153	158	5	3%
100	104	5	5%
73	78	5	7%
35	40	5	14%

Volume (vph)		Diff (vph)	%
Ex	Ch		
157	162	5	3%
1,259	1,264	5	0%
412	417	5	1%
283	288	5	2%
1,160	1,165	5	0%
1,025	1,030	5	0%
1,232	1,237	5	0%
113	117	5	4%
91	96	5	5%
51	56	5	9%
170	175	5	3%
703	708	5	1%
1,029	1,033	5	0%
871	875	5	1%
699	704	5	1%
84	89	5	5%
151	155	5	3%
73	78	5	6%
1,922	1,927	5	0%
1,391	1,396	5	0%
403	408	5	1%
197	201	5	2%
151	155	5	3%
184	189	4	2%
964	968	4	0%
638	642	4	1%
259	263	4	2%
1,211	1,215	4	0%
701	706	4	1%
455	460	4	1%
234	238	4	2%
204	208	4	2%
188	193	4	2%
1,200	1,205	4	0%
935	939	4	0%
50	54	4	8%
19	23	4	22%
19	23	4	22%
191	195	4	2%
179	183	4	2%
179	183	4	2%
1,150	1,155	4	0%
1,265	1,269	4	0%
885	889	4	0%
456	460	4	1%
306	310	4	1%
306	310	4	1%
191	195	4	2%
18	22	4	23%

Volume (vph)		Diff (vph)	%
Ex	Ch		
204	208	4	2%
151	155	4	3%
55	59	4	7%
153	157	4	2%
1,020	1,024	4	0%
455	458	4	1%
1,845	1,849	4	0%
1,474	1,478	4	0%
390	393	4	1%
24	28	4	15%
20	24	4	18%
159	163	4	2%
357	360	4	1%
226	229	4	2%
173	176	4	2%
74	78	4	5%
51	55	4	7%
20	24	4	18%
1,029	1,033	3	0%
217	220	3	2%
187	191	3	2%
131	134	3	3%
52	55	3	7%
637	640	3	1%
591	595	3	1%
589	593	3	1%
1,282	1,286	3	0%
36	39	3	9%
20	24	3	16%
12	15	3	28%
153	156	3	2%
776	779	3	0%
357	360	3	1%
893	896	3	0%
32	36	3	10%
19	22	3	17%
18	21	3	18%
593	596	3	1%
1,359	1,363	3	0%
1,399	1,402	3	0%
588	592	3	1%
302	305	3	1%
272	275	3	1%
260	263	3	1%
42	45	3	7%
132	135	3	2%
131	134	3	2%
131	134	3	2%
393	396	3	1%

Volume (vph)		Diff (vph)	%
Ex	Ch		
2,123	2,126	3	0%
1,141	1,144	3	0%
442	445	3	1%
306	309	3	1%
271	274	3	1%
173	176	3	2%
93	96	3	3%
76	79	3	4%
173	176	3	2%
163	166	3	2%
132	135	3	2%
43	46	3	7%
18	20	3	17%
17	20	3	17%
1,760	1,763	3	0%
2,111	2,114	3	0%
1,036	1,038	3	0%
999	1,002	3	0%
445	448	3	1%
166	168	3	2%
160	163	3	2%
113	115	3	2%
50	53	3	6%
21	24	3	13%
1,145	1,148	3	0%
777	779	3	0%
122	125	3	2%
95	97	3	3%
16	19	3	17%
377	380	3	1%
272	274	3	1%
891	894	3	0%
375	378	3	1%
243	246	3	1%
49	52	3	5%
31	34	3	8%
21	23	3	13%
100	103	3	3%
87	89	3	3%
378	380	3	1%
944	947	3	0%
208	211	3	1%
177	179	3	1%
113	116	3	2%
72	74	3	3%
21	23	3	12%
21	23	3	12%
1,795	1,798	2	0%
929	932	2	0%

Volume (vph)		Diff (vph)	%
Ex	Ch		
405	408	2	1%
362	365	2	1%
262	264	2	1%
123	125	2	2%
26	29	2	9%
5	8	2	47%
448	451	2	1%
443	445	2	1%
440	443	2	1%
270	273	2	1%
113	116	2	2%
48	50	2	5%
26	29	2	9%
25	27	2	9%
19	21	2	12%
7	10	2	31%
4	6	2	59%
892	894	2	0%
883	885	2	0%
311	313	2	1%
1,512	1,514	2	0%
1,471	1,474	2	0%
890	893	2	0%
777	779	2	0%
708	710	2	0%
225	227	2	1%
209	211	2	1%
72	74	2	3%
25	27	2	9%
400	402	2	1%
362	364	2	1%
311	314	2	1%
289	291	2	1%
639	641	2	0%
2,111	2,114	2	0%
1,555	1,557	2	0%
903	905	2	0%
268	270	2	1%
267	269	2	1%
68	70	2	3%
48	50	2	4%
48	50	2	4%
48	50	2	4%
249	251	2	1%
113	116	2	2%
64	66	2	3%
79	81	2	3%
78	80	2	3%
64	66	2	3%

Volume (vph)		Diff (vph)	%
Ex	Ch		
128	130	2	2%
355	357	2	1%
68	70	2	3%
68	70	2	3%
11	13	2	17%
11	13	2	18%
8	10	2	23%
596	598	2	0%
1,381	1,383	2	0%
928	930	2	0%
500	502	2	0%
118	120	2	2%
56	58	2	3%
48	50	2	4%
13	15	2	14%
8	10	2	22%
141	143	2	1%
881	883	2	0%
709	711	2	0%
591	592	2	0%
512	514	2	0%
194	196	2	1%
193	195	2	1%
123	124	2	1%
99	101	2	2%
98	100	2	2%
82	83	2	2%
63	65	2	3%
10	11	2	18%
282	284	2	1%
245	246	2	1%
101	103	2	2%
803	805	2	0%
929	931	2	0%
830	831	2	0%
710	711	2	0%
154	155	2	1%
106	107	2	2%
101	102	2	2%
94	96	2	2%
27	28	2	6%
97	98	2	2%
478	479	2	0%
471	472	2	0%
881	882	2	0%
478	479	2	0%
391	392	2	0%
316	317	2	0%
244	245	2	1%

Volume (vph)		Diff (vph)	%
Ex	Ch		
113	114	2	1%
103	105	2	1%
81	83	2	2%
81	83	2	2%
81	83	2	2%
15	17	2	10%
13	15	2	12%
312	314	1	0%
191	193	1	1%
141	142	1	1%
94	95	1	1%
40	41	1	4%
27	29	1	5%
23	24	1	6%
15	17	1	9%
890	891	1	0%
1,706	1,707	1	0%
99	101	1	1%
40	41	1	3%
31	33	1	4%
21	22	1	6%
13	14	1	10%
7	8	1	19%
7	8	1	19%
7	8	1	19%
7	8	1	19%
3	4	1	46%
799	800	1	0%
497	498	1	0%
1,235	1,236	1	0%
951	952	1	0%
606	607	1	0%
606	607	1	0%
455	457	1	0%
139	140	1	1%
97	98	1	1%
55	56	1	2%
54	55	1	2%
28	29	1	4%
7	8	1	18%
7	8	1	18%
1,248	1,249	1	0%
913	914	1	0%
607	608	1	0%
533	534	1	0%
201	202	1	1%
124	125	1	1%
78	79	1	1%
58	59	1	2%

Volume (vph)		Diff (vph)	%
Ex	Ch		
46	47	1	2%
31	33	1	4%
12	13	1	9%
7	8	1	16%
7	8	1	16%
55	56	1	2%
34	35	1	3%
315	316	1	0%
1,556	1,557	1	0%
1,584	1,585	1	0%
1,542	1,543	1	0%
1,034	1,035	1	0%
818	819	1	0%
817	818	1	0%
615	616	1	0%
64	65	1	2%
25	26	1	4%
23	24	1	4%
23	24	1	4%
18	19	1	5%
18	19	1	6%
8	9	1	13%
5	6	1	19%
5	6	1	19%
5	6	1	19%
5	6	1	20%
3	4	1	36%
1,642	1,643	1	0%
220	221	1	0%
202	203	1	0%
187	188	1	0%
187	188	1	0%
114	115	1	1%
71	72	1	1%
71	72	1	1%
7	8	1	13%
7	8	1	13%
64	65	1	1%
42	42	1	2%
35	36	1	3%
25	26	1	4%
23	24	1	4%
23	24	1	4%
23	24	1	4%
605	606	1	0%
1,672	1,673	1	0%
607	608	1	0%
212	213	1	0%
199	199	1	0%

Volume (vph)		Diff (vph)	%
Ex	Ch		
111	112	1	1%
18	19	1	4%
7	8	1	11%
1	2	1	114%
112	113	1	1%
107	108	1	1%
97	98	1	1%
35	35	1	2%
187	188	1	0%
605	606	1	0%
577	578	1	0%
536	536	1	0%
98	98	1	1%
12	12	1	6%
7	7	1	11%
2	3	1	29%
2	3	1	33%
2	3	1	33%
2	3	1	37%
2	3	1	37%
18	19	1	4%
46	47	1	2%
43	44	1	2%
501	502	1	0%
330	330	1	0%
294	294	1	0%
209	210	1	0%
153	154	1	0%
2,110	2,111	1	0%
916	917	1	0%
486	486	1	0%
100	100	1	1%
77	78	1	1%
51	51	1	1%
51	51	1	1%
44	44	1	1%
8	9	1	7%
8	8	1	8%
16	16	1	4%
16	16	1	4%
7	7	1	9%
2	2	1	35%
26	26	1	2%
180	181	1	0%
148	149	1	0%
119	120	1	1%
98	98	1	1%
61	61	1	1%
1,795	1,795	1	0%

Volume (vph)		Diff (vph)	%
Ex	Ch		
276	277	1	0%
84	84	1	1%
80	81	1	1%
74	74	1	1%
61	61	1	1%
17	17	1	3%
11	12	1	5%
8	9	1	6%
4	5	1	12%
3	3	1	19%
184	184	0	0%
106	107	0	0%
84	84	0	0%
29	30	0	1%
29	30	0	1%
23	23	0	2%
9	9	0	4%
45	45	0	1%
45	45	0	1%
25	26	0	2%
17	17	0	2%
15	15	0	3%
8	9	0	5%
470	471	0	0%
501	502	0	0%
500	500	0	0%
474	474	0	0%
276	276	0	0%
29	29	0	1%
22	23	0	1%
16	17	0	2%
14	14	0	2%
8	8	0	4%
1	2	0	21%
1	2	0	23%
1	1	0	60%
1	1	0	60%
1	1	0	60%
1	1	0	60%
0	1	0	75%
11	11	0	3%
51	52	0	1%
49	49	0	1%
34	34	0	1%
211	212	0	0%
1,888	1,888	0	0%
1,591	1,591	0	0%
1,537	1,537	0	0%
1,536	1,537	0	0%

Volume (vph)		Diff (vph)	%
Ex	Ch		
1,923	1,923	0	0%
552	552	0	0%
45	46	0	0%
45	45	0	0%
17	17	0	1%
5	5	0	4%
4	4	0	5%
2	2	0	10%
2	2	0	10%
2	2	0	10%
1	1	0	20%
1	1	0	20%
1	1	0	20%
1	1	0	22%
29	29	0	1%
14	15	0	1%
451	451	0	0%
245	245	0	0%
220	220	0	0%
205	206	0	0%
862	862	0	0%
1,702	1,702	0	0%
467	467	0	0%
202	202	0	0%
116	116	0	0%
80	80	0	0%
18	18	0	1%
18	18	0	1%
18	18	0	1%
9	9	0	1%
8	8	0	1%
4	4	0	3%
3	3	0	4%
2	2	0	6%
1	1	0	10%
1	1	0	20%
1	1	0	9%
14	14	0	1%
14	14	0	1%
10	10	0	1%
8	8	0	1%
5	5	0	2%
129	129	0	0%
62	62	0	0%
370	370	0	0%
1,545	1,546	0	0%
1,502	1,502	0	0%
1,364	1,364	0	0%
1,276	1,276	0	0%

Volume (vph)		Diff (vph)	%
Ex	Ch		
633	633	0	0%
502	502	0	0%
446	446	0	0%
203	203	0	0%
166	166	0	0%
166	166	0	0%
116	116	0	0%
80	80	0	0%
68	68	0	0%
48	48	0	0%
35	35	0	0%
34	34	0	0%
34	34	0	0%
33	33	0	0%
17	17	0	0%
17	17	0	0%
13	13	0	0%
10	10	0	0%
10	10	0	0%
9	9	0	0%
9	9	0	0%
8	8	0	0%
7	7	0	0%
4	4	0	0%
4	4	0	0%
4	4	0	0%
4	4	0	0%
4	4	0	0%
1	1	0	0%
0	0	0	0%
0	0	0	0%
1,310	1,310	0	0%
498	498	0	0%
191	191	0	0%
121	121	0	0%
78	78	0	0%
69	69	0	0%
56	56	0	0%
29	29	0	0%
19	19	0	-1%
16	16	0	-1%
16	16	0	-1%
14	13	0	-1%
3	3	0	-4%
7	7	0	-1%
7	7	0	-1%
7	7	0	-1%
43	42	0	0%
330	329	0	0%

Volume (vph)		Diff (vph)	%
Ex	Ch		
211	211	0	0%
136	136	0	0%
2,022	2,022	0	0%
580	580	0	0%
370	370	0	0%
337	337	0	0%
220	220	0	0%
191	191	0	0%
20	20	0	-1%
20	20	0	-1%
17	17	0	-1%
17	17	0	-1%
9	8	0	-2%
6	5	0	-4%
3	3	0	-6%
3	3	0	-6%
3	3	0	-6%
3	2	0	-8%
13	13	0	-2%
13	13	0	-2%
121	121	0	0%
101	101	0	0%
86	85	0	0%
25	24	0	-1%
192	192	0	0%
192	192	0	0%
1,794	1,794	0	0%
868	868	0	0%
379	379	0	0%
821	820	0	0%
192	192	0	0%
191	191	0	0%
191	191	0	0%
115	115	0	0%
85	84	0	0%
43	42	0	-1%
3	3	0	-9%
3	3	0	-9%
3	3	0	-9%
3	3	0	-9%
3	3	0	-9%
1	1	0	-21%
17	16	0	-2%
15	15	0	-2%
13	13	0	-2%
13	13	0	-2%
39	38	0	-1%
369	369	0	0%
353	353	0	0%

Volume (vph)		Diff (vph)	%
Ex	Ch		
307	307	0	0%
266	265	0	0%
175	175	0	0%
114	114	0	0%
65	65	0	0%
65	65	0	0%
659	659	0	0%
602	601	0	0%
287	286	0	0%
4	4	0	-9%
2	2	0	-19%
2	1	0	-24%
1	1	0	-44%
1	1	0	-44%
225	225	0	0%
176	175	0	0%
86	85	0	0%
78	78	0	-1%
70	69	0	-1%
66	66	0	-1%
1,621	1,621	-1	0%
1,237	1,237	-1	0%
368	368	-1	0%
266	265	-1	0%
266	265	-1	0%
139	139	-1	0%
126	125	-1	0%
122	122	-1	0%
66	66	-1	-1%
38	37	-1	-1%
24	24	-1	-2%
18	18	-1	-3%
227	226	-1	0%
15	14	-1	-4%
12	12	-1	-5%
6	5	-1	-11%
2	2	-1	-25%
2	2	-1	-25%
2	2	-1	-25%
2	1	-1	-30%
932	931	-1	0%
308	308	-1	0%
260	259	-1	0%
1,876	1,875	-1	0%
552	552	-1	0%
428	427	-1	0%
266	265	-1	0%
225	224	-1	0%
203	202	-1	0%

Volume (vph)		Diff (vph)	%
Ex	Ch		
31	31	-1	-2%
3	2	-1	-23%
64	64	-1	-1%
57	56	-1	-1%
36	35	-1	-2%
1,087	1,087	-1	0%
601	600	-1	0%
1,792	1,791	-1	0%
591	590	-1	0%
553	553	-1	0%
92	91	-1	-1%
11	10	-1	-7%
8	7	-1	-10%
5	4	-1	-16%
428	427	-1	0%
25	24	-1	-4%
12	11	-1	-8%
13	12	-1	-7%
4	3	-1	-23%
3	2	-1	-31%
26	25	-1	-3%
197	196	-1	0%
193	192	-1	0%
131	130	-1	-1%
1,696	1,695	-1	0%
351	350	-1	0%
286	285	-1	0%
227	226	-1	0%
150	149	-1	-1%
116	115	-1	-1%
116	115	-1	-1%
26	25	-1	-4%
19	18	-1	-5%
12	11	-1	-9%
10	9	-1	-10%
8	7	-1	-13%
40	39	-1	-3%
38	36	-1	-3%
6	5	-1	-19%
6	5	-1	-20%
5	4	-1	-21%
5	4	-1	-22%
3	2	-1	-41%
935	934	-1	0%
817	816	-1	0%
601	600	-1	0%
436	435	-1	0%
372	371	-1	0%
266	265	-1	0%

Volume (vph)		Diff (vph)	%
Ex	Ch		
88	87	-1	-1%
88	87	-1	-1%
57	56	-1	-2%
57	56	-1	-2%
41	40	-1	-3%
9	8	-1	-13%
7	6	-1	-17%
3	2	-1	-41%
3	2	-1	-41%
3	2	-1	-41%
3	2	-1	-41%
210	209	-1	-1%
611	610	-1	0%
30	29	-1	-4%
10	8	-1	-13%
7	5	-1	-19%
368	367	-1	0%
368	366	-1	0%
128	127	-1	-1%
14	13	-1	-10%
3	2	-1	-44%
3	1	-1	-56%
3	1	-1	-56%
3	1	-1	-56%
3	1	-1	-56%
188	186	-1	-1%
186	185	-1	-1%
2,109	2,108	-2	0%
238	237	-2	-1%
197	196	-2	-1%
165	164	-2	-1%
116	115	-2	-1%
69	68	-2	-2%
69	68	-2	-2%
32	31	-2	-5%
30	28	-2	-5%
27	25	-2	-6%
16	14	-2	-9%
14	13	-2	-10%
3	2	-2	-48%
232	231	-2	-1%
190	188	-2	-1%
140	139	-2	-1%
58	56	-2	-3%
58	56	-2	-3%
38	36	-2	-4%
13	12	-2	-12%
837	835	-2	0%
367	365	-2	0%

Volume (vph)		Diff (vph)	%
Ex	Ch		
267	265	-2	-1%
139	138	-2	-1%
345	343	-2	0%
180	178	-2	-1%
42	41	-2	-4%
42	41	-2	-4%
225	224	-2	-1%
161	160	-2	-1%
140	138	-2	-1%
139	138	-2	-1%
1,460	1,458	-2	0%
749	747	-2	0%
229	227	-2	-1%
61	59	-2	-3%
33	31	-2	-5%
13	11	-2	-14%
13	11	-2	-14%
169	167	-2	-1%
345	343	-2	-1%
947	945	-2	0%
435	433	-2	0%
168	166	-2	-1%
110	108	-2	-2%
41	39	-2	-5%
6	4	-2	-31%
155	152	-2	-1%
34	32	-2	-6%
21	19	-2	-10%
19	17	-2	-11%
12	10	-2	-17%
9	7	-2	-24%
9	7	-2	-24%
9	7	-2	-24%
7	5	-2	-30%
6	4	-2	-36%
6	4	-2	-36%
128	126	-2	-2%
107	105	-2	-2%
435	433	-2	0%
268	266	-2	-1%
39	37	-2	-6%
9	7	-2	-24%
9	7	-2	-25%
9	6	-2	-26%
9	6	-2	-26%
9	6	-2	-26%
5	3	-2	-42%
5	2	-2	-49%
5	2	-2	-49%

Volume (vph)		Diff (vph)	%
Ex	Ch		
5	2	-2	-49%
4	1	-2	-61%
1,295	1,293	-2	0%
1,082	1,080	-2	0%
344	342	-2	-1%
43	40	-2	-5%
9	7	-2	-26%
342	340	-2	-1%
268	266	-2	-1%
145	143	-2	-2%
376	374	-2	-1%
41	39	-2	-6%
13	11	-2	-18%
4	2	-2	-57%
205	202	-2	-1%
184	182	-2	-1%
155	152	-2	-2%
374	372	-2	-1%
318	315	-2	-1%
970	967	-3	0%
375	372	-3	-1%
166	164	-3	-2%
155	152	-3	-2%
147	144	-3	-2%
128	126	-3	-2%
109	106	-3	-2%
49	47	-3	-5%
34	32	-3	-7%
1,705	1,702	-3	0%
166	163	-3	-2%
155	152	-3	-2%
143	140	-3	-2%
143	140	-3	-2%
60	58	-3	-4%
35	32	-3	-8%
81	78	-3	-3%
166	164	-3	-2%
131	128	-3	-2%
131	128	-3	-2%
415	413	-3	-1%
145	142	-3	-2%
75	72	-3	-4%
127	125	-3	-2%
122	119	-3	-2%
1,705	1,702	-3	0%
1,457	1,454	-3	0%
1,322	1,319	-3	0%
879	876	-3	0%
122	119	-3	-2%

Volume (vph)		Diff (vph)	%
Ex	Ch		
107	104	-3	-3%
82	79	-3	-3%
49	46	-3	-6%
27	24	-3	-11%
19	16	-3	-15%
166	164	-3	-2%
306	303	-3	-1%
232	229	-3	-1%
199	196	-3	-1%
82	79	-3	-4%
71	68	-3	-4%
2,265	2,262	-3	0%
1,332	1,329	-3	0%
230	227	-3	-1%
136	133	-3	-2%
88	85	-3	-3%
82	79	-3	-4%
73	70	-3	-4%
139	136	-3	-2%
72	69	-3	-4%
37	34	-3	-8%
59	56	-3	-5%
73	70	-3	-4%
308	305	-3	-1%
200	197	-3	-2%
73	70	-3	-4%
73	70	-3	-4%
73	70	-3	-4%
33	30	-3	-10%
33	30	-3	-10%
25	22	-3	-13%
2,030	2,027	-3	0%
88	85	-3	-4%
54	51	-3	-6%
43	40	-3	-8%
354	351	-3	-1%
258	255	-3	-1%
219	216	-3	-2%
212	208	-3	-2%
157	154	-3	-2%
1,954	1,951	-3	0%
292	289	-3	-1%
129	125	-3	-3%
13	10	-3	-26%
198	194	-3	-2%
1,577	1,574	-3	0%
620	617	-3	-1%
1,452	1,448	-4	0%
943	939	-4	0%

Volume (vph)		Diff (vph)	%
Ex	Ch		
574	571	-4	-1%
196	193	-4	-2%
196	193	-4	-2%
12	8	-4	-30%
25	22	-4	-14%
884	880	-4	0%
883	880	-4	0%
293	289	-4	-1%
392	388	-4	-1%
385	381	-4	-1%
196	193	-4	-2%
146	143	-4	-3%
135	131	-4	-3%
623	619	-4	-1%
426	423	-4	-1%
635	631	-4	-1%
371	367	-4	-1%
57	53	-4	-7%
20	16	-4	-19%
230	226	-4	-2%
112	109	-4	-3%
129	125	-4	-3%
1,255	1,251	-4	0%
933	929	-4	0%
884	880	-4	0%
883	879	-4	0%
327	323	-4	-1%
219	215	-4	-2%
123	119	-4	-3%
1,278	1,274	-4	0%
218	214	-4	-2%
368	364	-4	-1%
1,882	1,878	-4	0%
132	128	-4	-3%
116	112	-4	-4%
65	61	-4	-6%
166	162	-4	-3%
132	128	-4	-3%
116	112	-4	-4%
137	132	-4	-3%
132	128	-4	-3%
884	879	-4	0%
65	61	-4	-7%
20	16	-4	-22%
160	156	-4	-3%
924	919	-4	0%
65	61	-4	-7%
2,269	2,265	-5	0%
1,317	1,312	-5	0%

Volume (vph)		Diff (vph)	%
Ex	Ch		
229	224	-5	-2%
224	220	-5	-2%
224	220	-5	-2%
220	216	-5	-2%
183	179	-5	-2%
166	162	-5	-3%
133	128	-5	-3%
73	69	-5	-6%
69	65	-5	-6%
22	17	-5	-21%
1,953	1,948	-5	0%
1,245	1,240	-5	0%
395	390	-5	-1%
290	286	-5	-2%
185	180	-5	-2%
129	125	-5	-4%
41	37	-5	-11%
20	16	-5	-23%
20	16	-5	-23%
16	11	-5	-30%
390	386	-5	-1%
181	176	-5	-3%
250	245	-5	-2%
228	224	-5	-2%
220	216	-5	-2%
42	37	-5	-11%
185	180	-5	-3%
185	180	-5	-3%
1,285	1,280	-5	0%
411	406	-5	-1%
1,274	1,270	-5	0%
1,260	1,255	-5	0%
314	310	-5	-2%
180	175	-5	-3%
95	90	-5	-5%
69	64	-5	-7%
27	22	-5	-18%
67	62	-5	-7%
166	161	-5	-3%
149	144	-5	-3%
390	385	-5	-1%
1,951	1,946	-5	0%
2,051	2,046	-5	0%
407	402	-5	-1%
303	298	-5	-2%
250	245	-5	-2%
49	44	-5	-10%
207	202	-5	-2%
975	970	-5	-1%

Volume (vph)		Diff (vph)	%
Ex	Ch		
390	385	-5	-1%
21	16	-5	-24%
21	16	-5	-25%
7	2	-5	-76%
7	2	-5	-76%
229	224	-5	-2%
974	969	-5	-1%
353	348	-5	-2%
109	103	-5	-5%
64	58	-5	-8%
21	16	-5	-25%
808	803	-5	-1%
975	969	-5	-1%
64	59	-5	-8%
22	16	-5	-25%
10	4	-5	-55%
141	136	-5	-4%
108	103	-5	-5%
10	4	-6	-56%
8	3	-6	-68%
1,245	1,239	-6	0%
353	347	-6	-2%
353	347	-6	-2%
356	351	-6	-2%
186	181	-6	-3%
186	181	-6	-3%
112	106	-6	-5%
1,532	1,526	-6	0%
982	976	-6	-1%
977	971	-6	-1%
27	21	-6	-22%
199	193	-6	-3%
1,242	1,236	-6	0%
92	86	-6	-7%
51	45	-6	-12%
1,267	1,261	-6	0%
211	205	-6	-3%
76	70	-6	-8%
84	77	-6	-7%
1,269	1,262	-7	-1%
115	108	-7	-6%
100	93	-7	-7%
317	311	-7	-2%
312	306	-7	-2%
101	94	-7	-7%
81	74	-7	-8%
115	108	-7	-6%
65	58	-7	-10%
65	58	-7	-10%

Volume (vph)		Diff (vph)	%
Ex	Ch		
159	152	-7	-4%
148	141	-7	-5%
1,372	1,366	-7	-1%
475	468	-7	-1%
65	58	-7	-11%
114	107	-7	-6%
341	334	-7	-2%
101	94	-7	-7%
1,506	1,498	-7	0%
1,506	1,498	-7	0%
187	180	-7	-4%
137	130	-7	-5%
1,506	1,499	-7	0%
891	884	-7	-1%
467	460	-7	-2%
1,269	1,261	-7	-1%
1,507	1,499	-8	-1%
167	160	-8	-5%
167	160	-8	-5%
138	130	-8	-6%
98	90	-8	-8%
475	467	-8	-2%
1,507	1,500	-8	-1%
81	73	-8	-10%
239	231	-8	-3%
891	883	-8	-1%
414	406	-8	-2%
98	90	-8	-8%
75	67	-8	-10%
164	157	-8	-5%
423	415	-8	-2%
1,222	1,214	-8	-1%
33	25	-8	-24%
33	25	-8	-24%
845	837	-8	-1%
432	424	-8	-2%
176	168	-8	-5%
1,292	1,284	-8	-1%
1,216	1,207	-8	-1%
92	84	-8	-9%
328	320	-8	-3%
190	182	-8	-4%
357	348	-8	-2%
142	134	-9	-6%
93	84	-9	-9%
284	275	-9	-3%
136	127	-9	-6%
341	333	-9	-3%
162	153	-9	-5%

Volume (vph)		Diff (vph)	%
Ex	Ch		
1,851	1,842	-9	0%
1,850	1,841	-9	0%
292	284	-9	-3%
242	233	-9	-4%
1,108	1,099	-9	-1%
156	147	-9	-6%
90	81	-9	-10%
191	182	-9	-5%
1,205	1,196	-9	-1%
159	150	-9	-6%
279	270	-9	-3%
234	224	-9	-4%
891	881	-9	-1%
37	28	-9	-25%
1,357	1,347	-9	-1%
1,388	1,379	-10	-1%
1,216	1,206	-10	-1%
738	728	-10	-1%
280	270	-10	-3%
286	276	-10	-3%
82	72	-10	-12%
497	487	-10	-2%
82	72	-10	-12%
361	351	-10	-3%
1,848	1,838	-10	-1%
1,282	1,272	-10	-1%
1,108	1,098	-10	-1%
2,120	2,110	-10	0%
1,261	1,251	-10	-1%
352	342	-10	-3%
294	284	-10	-3%
218	208	-10	-5%
20	10	-10	-50%
868	858	-10	-1%
295	285	-10	-4%
2,122	2,112	-11	0%
327	316	-11	-3%
170	159	-11	-6%
1,634	1,624	-11	-1%
2,119	2,109	-11	-1%
1,189	1,178	-11	-1%
1,305	1,294	-11	-1%
1,282	1,271	-11	-1%
1,281	1,270	-11	-1%
990	979	-11	-1%
58	47	-11	-19%
1,339	1,328	-11	-1%
1,074	1,063	-11	-1%
169	158	-11	-7%

Volume (vph)		Diff (vph)	%
Ex	Ch		
169	158	-11	-7%
1,075	1,063	-11	-1%
204	192	-11	-6%
204	192	-11	-6%
1,155	1,144	-11	-1%
1,282	1,271	-11	-1%
54	42	-11	-21%
1,107	1,095	-12	-1%
171	160	-12	-7%
413	401	-12	-3%
1,985	1,974	-12	-1%
670	658	-12	-2%
143	131	-12	-8%
2,490	2,478	-12	0%
1,845	1,833	-12	-1%
1,184	1,172	-12	-1%
668	656	-12	-2%
2,125	2,113	-12	-1%
2,115	2,103	-12	-1%
1,628	1,616	-12	-1%
1,307	1,294	-12	-1%
1,266	1,253	-12	-1%
1,197	1,185	-12	-1%
425	412	-12	-3%
1,624	1,612	-12	-1%
850	838	-13	-1%
242	230	-13	-5%
1,263	1,250	-13	-1%
371	359	-13	-3%
171	158	-13	-7%
2,498	2,485	-13	-1%
240	228	-13	-5%
211	198	-13	-6%
1,224	1,211	-13	-1%
193	180	-13	-7%
1,984	1,971	-13	-1%
368	355	-13	-4%
212	199	-13	-6%
1,842	1,829	-13	-1%
33	20	-13	-41%
1,389	1,376	-13	-1%
1,400	1,386	-14	-1%
768	755	-14	-2%
435	421	-14	-3%
996	983	-14	-1%
376	362	-14	-4%
333	319	-14	-4%
1,647	1,634	-14	-1%
194	180	-14	-7%

Volume (vph)		Diff (vph)	%
Ex	Ch		
711	697	-14	-2%
227	213	-14	-6%
1,605	1,591	-14	-1%
170	156	-14	-8%
1,227	1,212	-14	-1%
623	609	-14	-2%
442	428	-14	-3%
194	180	-14	-7%
227	213	-14	-6%
911	896	-14	-2%
442	427	-14	-3%
1,982	1,968	-14	-1%
1,651	1,636	-15	-1%
1,840	1,825	-15	-1%
167	153	-15	-9%
666	651	-15	-2%
355	340	-15	-4%
1,501	1,486	-15	-1%
1,410	1,395	-15	-1%
879	864	-15	-2%
294	279	-15	-5%
1,660	1,644	-15	-1%
1,501	1,485	-15	-1%
1,137	1,121	-15	-1%
1,655	1,639	-16	-1%
916	901	-16	-2%
1,133	1,118	-16	-1%
971	955	-16	-2%
1,188	1,172	-16	-1%
1,117	1,102	-16	-1%
662	646	-16	-2%
175	159	-16	-9%
175	159	-16	-9%
878	862	-16	-2%
1,658	1,642	-16	-1%
1,653	1,637	-16	-1%
1,935	1,918	-16	-1%
261	244	-16	-6%
426	409	-17	-4%
457	440	-17	-4%
1,611	1,594	-17	-1%
1,233	1,216	-17	-1%
1,520	1,503	-17	-1%
1,002	985	-17	-2%
465	448	-17	-4%
1,554	1,537	-17	-1%
796	779	-17	-2%
1,610	1,593	-17	-1%
465	448	-18	-4%

Volume (vph)		Diff (vph)	%
Ex	Ch		
1,555	1,537	-18	-1%
1,553	1,535	-18	-1%
1,647	1,629	-18	-1%
354	336	-18	-5%
1,419	1,401	-18	-1%
1,410	1,392	-18	-1%
293	274	-18	-6%
1,419	1,401	-18	-1%
654	635	-18	-3%
258	239	-18	-7%
999	981	-19	-2%
878	860	-19	-2%
1,173	1,154	-19	-2%
863	844	-19	-2%
1,207	1,188	-19	-2%
861	841	-19	-2%
204	185	-19	-10%
2,226	2,206	-20	-1%
1,259	1,239	-20	-2%
1,245	1,225	-20	-2%
201	180	-20	-10%
2,224	2,204	-21	-1%
1,256	1,235	-21	-2%
1,256	1,235	-21	-2%
614	593	-21	-3%
1,407	1,386	-21	-1%
1,085	1,064	-21	-2%
542	521	-21	-4%
30	9	-21	-70%
30	9	-21	-70%
30	9	-21	-70%
30	9	-21	-70%
618	597	-21	-3%
30	9	-21	-70%
1,313	1,292	-22	-2%
1,323	1,301	-22	-2%
251	229	-22	-9%
679	657	-22	-3%
168	146	-22	-13%
1,718	1,696	-22	-1%
251	228	-23	-9%
677	654	-23	-3%
1,183	1,160	-23	-2%
1,134	1,111	-23	-2%
1,135	1,111	-24	-2%
2,110	2,086	-24	-1%
2,164	2,140	-24	-1%
2,127	2,103	-24	-1%
1,541	1,517	-24	-2%

Volume (vph)		Diff (vph)	%
Ex	Ch		
1,413	1,388	-25	-2%
1,356	1,331	-25	-2%
140	115	-26	-18%
1,752	1,726	-26	-1%
1,730	1,704	-26	-1%
1,399	1,373	-26	-2%
1,394	1,368	-26	-2%
230	204	-26	-11%
141	115	-26	-19%
141	115	-26	-19%
1,391	1,364	-26	-2%
229	202	-27	-12%
1,807	1,780	-27	-1%
1,571	1,544	-27	-2%
228	201	-27	-12%
2,359	2,332	-27	-1%
2,135	2,108	-27	-1%
1,088	1,061	-28	-3%
1,139	1,111	-28	-2%
2,119	2,091	-28	-1%
513	485	-28	-6%
1,137	1,108	-29	-3%
2,357	2,328	-29	-1%
1,820	1,791	-29	-2%
521	491	-30	-6%
1,813	1,784	-30	-2%
885	853	-32	-4%
1,938	1,905	-33	-2%
998	966	-33	-3%
998	965	-33	-3%
998	964	-34	-3%
893	860	-34	-4%
2,140	2,104	-35	-2%
532	496	-36	-7%
2,262	2,226	-36	-2%
528	491	-37	-7%
2,259	2,221	-38	-2%
2,255	2,217	-38	-2%
1,285	1,246	-39	-3%
2,244	2,204	-40	-2%
2,235	2,195	-40	-2%
2,227	2,187	-40	-2%
1,283	1,243	-40	-3%
2,231	2,190	-41	-2%
2,072	2,031	-41	-2%
2,077	2,035	-42	-2%
1,731	1,682	-49	-3%
1,732	1,682	-50	-3%

APPENDIX A14

PM CBD Network Testing Link Volumes

Notes:

Ex = Existing Rule (farside priority)

Ch = Changed Rule (nearside priority)

Diff = Difference (Existing – Changed)

% = Percentage Change (Difference/Existing)

Data presented in order of descending difference

Volume (vph)		Diff (vph)	%
Ex	Ch		
577	738	161	28%
574	729	155	27%
474	552	79	17%
491	566	75	15%
149	224	75	51%
152	227	75	49%
143	217	74	52%
144	217	73	51%
319	392	73	23%
88	161	73	83%
85	158	73	85%
325	394	70	21%
92	161	69	74%
245	305	60	25%
245	304	59	24%
659	715	56	8%
566	622	56	10%
526	581	55	10%
526	581	55	10%
879	934	54	6%
535	587	52	10%
535	587	52	10%
817	869	52	6%
814	866	52	6%
368	418	50	14%
603	652	49	8%
577	625	48	8%
1,477	1,525	48	3%
405	453	48	12%
604	652	48	8%
1,477	1,525	48	3%
1,134	1,182	48	4%
1,477	1,525	48	3%
1,134	1,182	47	4%
684	731	47	7%
1,135	1,182	47	4%
188	234	46	25%
291	336	46	16%
1,472	1,518	46	3%
1,472	1,518	46	3%
2,059	2,102	43	2%
424	466	42	10%
293	335	42	14%
443	485	42	9%
375	416	41	11%
423	464	40	10%
481	520	39	8%
524	563	39	7%
420	458	38	9%
420	458	38	9%
525	563	38	7%
425	463	38	9%
361	399	38	10%
291	329	37	13%
523	561	37	7%

Volume (vph)		Diff (vph)	%
Ex	Ch		
465	502	37	8%
422	460	37	9%
293	330	37	13%
288	325	37	13%
266	302	36	14%
288	325	36	13%
67	103	36	54%
287	323	36	13%
516	551	34	7%
481	515	34	7%
420	453	33	8%
286	319	33	12%
287	319	32	11%
1,828	1,860	32	2%
1,828	1,860	32	2%
287	317	30	11%
410	440	30	7%
412	441	30	7%
425	454	29	7%
259	288	29	11%
425	454	29	7%
91	119	28	30%
1,185	1,213	28	2%
1,269	1,297	28	2%
60	87	27	46%
1,185	1,212	27	2%
206	233	27	13%
427	454	27	6%
231	257	26	11%
368	394	26	7%
211	237	26	12%
169	195	26	15%
238	264	26	11%
354	379	25	7%
593	617	24	4%
320	344	24	8%
2,069	2,093	24	1%
599	623	24	4%
258	281	24	9%
436	459	23	5%
363	386	23	6%
570	593	23	4%
188	212	23	12%
613	637	23	4%
2,082	2,105	23	1%
258	281	23	9%
614	637	23	4%
309	332	23	7%
601	623	23	4%
720	742	22	3%
720	742	22	3%
821	843	22	3%
2,083	2,105	22	1%
2,154	2,176	22	1%
614	635	22	4%

Volume (vph)		Diff (vph)	%
Ex	Ch		
821	843	21	3%
2,157	2,178	21	1%
1,854	1,875	21	1%
1,856	1,877	21	1%
64	85	21	33%
1,856	1,877	21	1%
361	381	21	6%
421	441	21	5%
821	842	21	3%
463	483	20	4%
2,157	2,177	20	1%
1,856	1,875	20	1%
40	60	20	49%
40	60	20	49%
456	476	20	4%
203	221	19	9%
566	585	19	3%
387	406	19	5%
2,150	2,169	19	1%
475	493	19	4%
596	615	19	3%
2,151	2,169	19	1%
574	593	19	3%
496	515	19	4%
476	494	19	4%
276	295	19	7%
203	221	19	9%
496	515	19	4%
2,066	2,084	19	1%
276	295	19	7%
567	585	18	3%
834	852	18	2%
457	475	18	4%
834	852	18	2%
597	615	18	3%
597	615	18	3%
287	305	18	6%
834	852	18	2%
273	290	18	7%
456	474	18	4%
493	511	18	4%
731	749	18	2%
1,405	1,423	18	1%
380	398	18	5%
2,151	2,169	18	1%
489	506	18	4%
1,406	1,423	17	1%
512	529	17	3%
1,652	1,669	17	1%
934	951	17	2%
1,652	1,669	17	1%
1,490	1,507	17	1%
42	59	17	40%
476	493	17	4%
288	304	17	6%

Volume (vph)		Diff (vph)	%
Ex	Ch		
365	381	17	5%
1,406	1,422	17	1%
1,660	1,676	16	1%
1,660	1,676	16	1%
436	452	16	4%
1,879	1,895	15	1%
272	287	15	6%
444	459	15	3%
964	979	15	2%
1,407	1,422	15	1%
1,661	1,676	15	1%
302	317	15	5%
399	414	15	4%
425	439	15	4%
668	683	15	2%
123	138	15	12%
343	358	15	4%
439	454	15	3%
936	951	15	2%
126	141	15	12%
126	140	15	12%
126	140	15	12%
174	188	15	8%
2,083	2,098	15	1%
176	190	15	8%
268	282	14	5%
263	277	14	5%
418	432	14	3%
405	419	14	3%
195	209	14	7%
669	683	14	2%
1,875	1,888	14	1%
2,138	2,152	14	1%
2,138	2,152	13	1%
299	312	13	4%
425	438	13	3%
550	563	13	2%
794	807	13	2%
425	438	13	3%
550	563	13	2%
2,138	2,151	13	1%
323	336	13	4%
232	245	13	5%
1,866	1,879	13	1%
1,864	1,877	13	1%
2,245	2,257	13	1%
297	309	13	4%
794	807	13	2%
128	141	12	10%
123	135	12	10%
753	765	12	2%
241	254	12	5%
1,512	1,524	12	1%
794	807	12	2%
450	462	12	3%

Volume (vph)		Diff (vph)	%
Ex	Ch		
138	150	12	9%
192	204	12	6%
1,512	1,524	12	1%
250	262	12	5%
1,512	1,524	12	1%
735	747	12	2%
250	262	12	5%
250	262	12	5%
183	195	12	6%
744	756	11	2%
735	746	11	2%
763	774	11	1%
350	361	11	3%
1,718	1,729	11	1%
99	109	11	11%
34	45	11	32%
1,081	1,091	11	1%
2,223	2,233	11	0%
2,061	2,071	11	1%
504	515	11	2%
235	246	11	4%
1,610	1,621	11	1%
550	560	10	2%
1,610	1,621	10	1%
1,610	1,621	10	1%
231	241	10	5%
1,130	1,140	10	1%
256	266	10	4%
256	266	10	4%
350	360	10	3%
1,759	1,769	10	1%
119	129	10	8%
873	883	10	1%
505	514	10	2%
255	265	10	4%
60	70	10	16%
1,673	1,683	10	1%
255	264	10	4%
1,945	1,954	10	0%
16	26	10	60%
256	266	10	4%
1,943	1,952	10	0%
160	170	10	6%
153	163	10	6%
160	170	10	6%
232	241	9	4%
2,275	2,285	9	0%
160	170	9	6%
844	853	9	1%
814	824	9	1%
1,771	1,780	9	1%
1,227	1,236	9	1%
343	352	9	3%
1,915	1,924	9	0%
1,772	1,780	9	1%

Volume (vph)		Diff (vph)	%
Ex	Ch		
844	853	9	1%
137	146	9	7%
344	352	9	3%
1,771	1,780	9	0%
1,838	1,846	9	0%
177	186	9	5%
2,039	2,047	9	0%
1,771	1,780	9	0%
36	44	9	24%
149	157	8	6%
465	473	8	2%
665	673	8	1%
1,116	1,124	8	1%
1,920	1,928	8	0%
1,432	1,440	8	1%
36	44	8	23%
1,772	1,780	8	0%
344	352	8	2%
216	224	8	4%
1,358	1,366	8	1%
284	292	8	3%
1,883	1,891	8	0%
130	138	8	6%
1,883	1,891	8	0%
1,772	1,780	8	0%
1,358	1,365	8	1%
1,227	1,235	8	1%
1,358	1,365	8	1%
149	157	8	5%
1,883	1,891	8	0%
231	239	8	3%
216	224	8	4%
1,054	1,062	8	1%
1,200	1,207	8	1%
373	381	8	2%
52	60	8	14%
460	467	7	2%
115	123	7	6%
809	817	7	1%
213	220	7	3%
521	529	7	1%
1,043	1,050	7	1%
474	481	7	2%
2,073	2,081	7	0%
130	137	7	5%
1,107	1,115	7	1%
1,199	1,206	7	1%
213	220	7	3%
21	28	7	33%
112	119	7	6%
255	262	7	3%
355	361	7	2%
1,025	1,031	7	1%
1,445	1,451	7	0%
78	84	7	9%

Volume (vph)		Diff (vph)	%
Ex	Ch		
282	289	7	2%
1,723	1,730	7	0%
1,449	1,456	7	0%
1,919	1,926	7	0%
78	85	7	8%
60	67	7	11%
255	261	7	3%
250	256	7	3%
234	241	7	3%
233	240	7	3%
78	85	7	8%
78	85	7	8%
234	241	7	3%
78	85	7	8%
78	85	7	8%
477	484	6	1%
71	78	6	9%
303	310	6	2%
232	238	6	3%
1,025	1,031	6	1%
37	44	6	17%
15	21	6	42%
232	238	6	3%
629	635	6	1%
844	850	6	1%
51	57	6	12%
15	21	6	41%
1,348	1,354	6	0%
1,870	1,876	6	0%
87	93	6	7%
317	323	6	2%
151	157	6	4%
51	57	6	12%
63	69	6	9%
479	485	6	1%
223	228	6	3%
98	104	6	6%
205	211	6	3%
1,721	1,727	6	0%
1,169	1,174	6	0%
26	32	6	22%
100	105	6	6%
1,356	1,361	6	0%
23	28	6	24%
881	887	6	1%
1,389	1,395	6	0%
185	191	6	3%
99	104	5	5%
275	281	5	2%
881	887	5	1%
164	170	5	3%
960	965	5	1%
959	965	5	1%
100	105	5	5%
100	105	5	5%

Volume (vph)		Diff (vph)	%
Ex	Ch		
1,051	1,057	5	0%
2,278	2,283	5	0%
2,191	2,196	5	0%
213	218	5	2%
213	218	5	2%
882	886	5	1%
1,525	1,530	5	0%
213	218	5	2%
414	419	5	1%
66	71	5	7%
357	362	5	1%
588	593	5	1%
370	375	5	1%
185	190	5	2%
132	137	5	3%
132	137	5	3%
150	154	5	3%
1,802	1,806	5	0%
1,053	1,058	5	0%
413	417	5	1%
63	67	4	7%
1,140	1,144	4	0%
301	306	4	1%
275	279	4	2%
1,818	1,822	4	0%
1,057	1,061	4	0%
435	440	4	1%
1,232	1,237	4	0%
1,155	1,159	4	0%
142	146	4	3%
237	241	4	2%
150	154	4	3%
215	219	4	2%
1,021	1,025	4	0%
150	154	4	3%
978	982	4	0%
138	142	4	3%
110	114	4	4%
1,738	1,742	4	0%
869	873	4	0%
338	342	4	1%
495	499	4	1%
281	285	4	1%
150	154	4	3%
103	107	4	4%
1,600	1,604	4	0%
120	124	4	3%
95	99	4	4%
252	256	4	2%
106	110	4	4%
292	296	4	1%
1,738	1,742	4	0%
138	141	4	3%
337	341	4	1%
487	491	4	1%

Volume (vph)		Diff (vph)	%
Ex	Ch		
216	219	4	2%
53	57	4	7%
35	39	4	11%
131	135	4	3%
567	571	4	1%
1,155	1,159	4	0%
90	93	4	4%
35	39	4	11%
35	39	4	11%
7	11	4	52%
33	37	4	11%
376	379	4	1%
398	402	4	1%
496	499	4	1%
443	446	4	1%
754	758	4	0%
697	700	4	1%
683	686	4	1%
622	626	4	1%
85	89	4	4%
85	89	4	4%
123	127	4	3%
276	279	4	1%
205	208	4	2%
275	278	4	1%
803	806	4	0%
986	989	4	0%
598	601	4	1%
1,282	1,285	4	0%
1,738	1,741	3	0%
138	141	3	2%
118	121	3	3%
869	872	3	0%
250	253	3	1%
1,319	1,323	3	0%
93	97	3	4%
103	106	3	3%
28	31	3	12%
398	401	3	1%
250	253	3	1%
20	23	3	16%
20	23	3	16%
420	423	3	1%
817	820	3	0%
192	195	3	2%
192	195	3	2%
219	222	3	1%
530	533	3	1%
697	700	3	0%
437	440	3	1%
1,366	1,369	3	0%
12	15	3	24%
1,154	1,157	3	0%
44	47	3	7%
1,334	1,337	3	0%

Volume (vph)		Diff (vph)	%
Ex	Ch		
1,321	1,323	3	0%
418	421	3	1%
615	618	3	0%
683	686	3	0%
1,320	1,323	3	0%
24	27	3	12%
27	30	3	10%
1,830	1,833	3	0%
1,053	1,055	3	0%
1,281	1,284	3	0%
208	211	3	1%
135	138	3	2%
140	142	3	2%
63	66	3	4%
48	51	3	6%
903	906	3	0%
870	872	3	0%
1,052	1,055	3	0%
1,330	1,332	3	0%
599	602	3	0%
87	90	3	3%
81	83	3	3%
211	214	3	1%
179	182	3	1%
1,053	1,055	3	0%
1,803	1,806	3	0%
903	906	3	0%
99	101	3	3%
698	700	3	0%
117	120	3	2%
7	9	3	38%
0	3	3	1250%
869	872	3	0%
616	618	3	0%
12	14	3	22%
455	457	3	1%
435	438	3	1%
212	215	2	1%
212	215	2	1%
99	101	2	2%
99	101	2	2%
97	99	2	2%
186	188	2	1%
2	4	2	133%
2	4	2	133%
0	3	2	1200%
0	3	2	1200%
21	23	2	12%
49	52	2	5%
268	271	2	1%
429	432	2	1%
617	619	2	0%
213	216	2	1%
213	215	2	1%
361	363	2	1%

Volume (vph)		Diff (vph)	%
Ex	Ch		
136	138	2	2%
436	438	2	1%
139	141	2	2%
19	21	2	12%
0	3	2	1150%
0	3	2	1150%
65	67	2	4%
97	99	2	2%
100	103	2	2%
42	44	2	6%
137	140	2	2%
981	983	2	0%
404	406	2	1%
1,175	1,177	2	0%
573	575	2	0%
100	103	2	2%
1,682	1,684	2	0%
458	461	2	0%
548	550	2	0%
136	138	2	2%
769	771	2	0%
18	21	2	11%
2	4	2	117%
2	4	2	117%
2	4	2	117%
18	20	2	11%
180	182	2	1%
39	41	2	5%
404	406	2	1%
1,529	1,531	2	0%
354	356	2	1%
902	904	2	0%
430	432	2	0%
355	357	2	1%
68	70	2	3%
270	272	2	1%
270	272	2	1%
101	103	2	2%
280	282	2	1%
135	137	2	1%
60	62	2	3%
9	11	2	23%
368	370	2	1%
161	163	2	1%
1,545	1,546	2	0%
299	301	2	1%
18	20	2	10%
18	20	2	10%
47	49	2	4%
12	14	2	15%
325	327	2	1%
180	182	2	1%
23	25	2	8%
3	5	2	53%
5	7	2	33%

Volume (vph)		Diff (vph)	%
Ex	Ch		
5	7	2	33%
5	7	2	33%
68	70	2	3%
138	140	2	1%
1,559	1,561	2	0%
1,053	1,055	2	0%
354	356	2	0%
1,544	1,545	2	0%
58	60	2	3%
34	36	2	5%
121	122	2	1%
15	17	2	11%
3	5	2	61%
11	13	2	15%
322	324	2	1%
322	324	2	1%
161	163	2	1%
174	176	2	1%
1,528	1,530	2	0%
282	283	2	1%
619	620	2	0%
93	95	2	2%
63	65	2	3%
3	4	2	57%
17	19	2	9%
63	65	2	3%
362	364	2	0%
1,135	1,137	2	0%
31	33	2	5%
605	606	2	0%
605	606	2	0%
606	607	2	0%
565	566	2	0%
57	59	2	3%
59	60	2	3%
1,054	1,055	2	0%
870	872	2	0%
34	36	2	4%
1,331	1,333	2	0%
455	457	2	0%
24	25	2	6%
109	111	2	1%
138	139	2	1%
483	485	2	0%
76	78	2	2%
917	918	2	0%
1,250	1,252	1	0%
325	327	1	0%
167	169	1	1%
2	3	1	93%
50	51	1	3%
57	59	1	2%
121	122	1	1%
606	607	1	0%
870	871	1	0%

Volume (vph)		Diff (vph)	%
Ex	Ch		
161	162	1	1%
446	447	1	0%
1,028	1,029	1	0%
911	913	1	0%
345	347	1	0%
445	446	1	0%
446	447	1	0%
50	51	1	3%
50	51	1	3%
31	33	1	4%
88	89	1	1%
50	51	1	3%
50	51	1	3%
699	700	1	0%
1,090	1,091	1	0%
1,624	1,625	1	0%
1,136	1,137	1	0%
1,152	1,153	1	0%
87	89	1	1%
36	37	1	3%
23	24	1	5%
312	313	1	0%
167	169	1	1%
302	303	1	0%
559	560	1	0%
1,723	1,725	1	0%
1,336	1,337	1	0%
1,077	1,078	1	0%
1,624	1,625	1	0%
312	313	1	0%
105	106	1	1%
44	45	1	2%
34	35	1	3%
56	57	1	2%
37	38	1	3%
55	56	1	2%
7	8	1	17%
7	8	1	17%
17	18	1	6%
17	18	1	6%
17	18	1	7%
145	146	1	1%
457	458	1	0%
1,545	1,546	1	0%
1,083	1,084	1	0%
1,083	1,084	1	0%
1,454	1,455	1	0%
15	16	1	7%
1,091	1,092	1	0%
1,077	1,078	1	0%
1,492	1,493	1	0%
238	239	1	0%
238	239	1	0%
17	18	1	6%
7	8	1	15%

Volume (vph)		Diff (vph)	%
Ex	Ch		
354	355	1	0%
87	88	1	1%
10	11	1	10%
44	45	1	2%
240	241	1	0%
56	57	1	2%
1,083	1,084	1	0%
259	260	1	0%
312	313	1	0%
238	239	1	0%
18	19	1	5%
3	4	1	27%
1	2	1	100%
39	40	1	2%
48	49	1	2%
33	34	1	3%
813	814	1	0%
459	460	1	0%
919	920	1	0%
1,454	1,455	1	0%
296	297	1	0%
507	508	1	0%
19	20	1	4%
24	24	1	3%
100	101	1	1%
81	82	1	1%
129	130	1	1%
1,250	1,251	1	0%
587	588	1	0%
1,415	1,416	1	0%
1,951	1,951	1	0%
138	139	1	1%
32	33	1	2%
64	65	1	1%
43	44	1	2%
3	3	1	26%
12	13	1	6%
19	19	1	4%
48	49	1	1%
481	482	1	0%
239	240	1	0%
1,346	1,347	1	0%
948	949	1	0%
171	172	1	0%
794	794	1	0%
111	112	1	1%
9	9	1	7%
9	9	1	7%
26	26	1	2%
15	15	1	4%
2	3	1	25%
1	1	1	120%
1	1	1	120%
1	1	1	120%
14	14	1	4%

Volume (vph)		Diff (vph)	%
Ex	Ch		
24	24	1	3%
244	245	1	0%
107	108	1	1%
129	129	1	0%
138	139	1	0%
112	113	1	1%
87	88	1	1%
294	294	1	0%
1,918	1,919	1	0%
12	12	1	4%
12	12	1	4%
12	12	1	4%
481	482	1	0%
12	12	1	4%
1,344	1,345	1	0%
15	16	1	3%
1	2	1	50%
1	2	1	50%
56	57	1	1%
1	2	1	50%
1	2	1	50%
126	127	1	0%
119	119	1	0%
111	111	1	0%
239	240	1	0%
138	138	1	0%
890	891	0	0%
361	362	0	0%
92	92	0	0%
88	88	0	0%
140	140	0	0%
148	148	0	0%
115	116	0	0%
149	150	0	0%
92	92	0	0%
196	196	0	0%
12	12	0	3%
12	12	0	3%
12	12	0	3%
12	12	0	3%
12	12	0	3%
0	0	0	#####
4	4	0	11%
4	5	0	9%
4	4	0	11%
16	16	0	3%
96	97	0	0%
265	265	0	0%
935	936	0	0%
88	88	0	0%
422	422	0	0%
189	190	0	0%
312	313	0	0%
304	304	0	0%
49	49	0	1%

Volume (vph)		Diff (vph)	%
Ex	Ch		
8	8	0	4%
1	1	0	43%
0	0	0	#####
103	103	0	0%
103	103	0	0%
1,411	1,411	0	0%
140	140	0	0%
84	84	0	0%
42	42	0	0%
19	19	0	1%
19	19	0	1%
10	10	0	2%
7	7	0	3%
1	2	0	14%
1	2	0	14%
1	1	0	40%
1	1	0	25%
39	39	0	1%
141	141	0	0%
941	941	0	0%
577	577	0	0%
1,066	1,066	0	0%
1,345	1,345	0	0%
480	480	0	0%
258	258	0	0%
588	588	0	0%
116	116	0	0%
9	9	0	1%
39	39	0	0%
64	64	0	0%
52	52	0	0%
52	52	0	0%
6	6	0	2%
1	1	0	10%
0	0	0	#####
0	1	0	25%
17	17	0	1%
50	50	0	0%
84	84	0	0%
203	203	0	0%
159	159	0	0%
123	123	0	0%
9	9	0	0%
9	9	0	0%
163	163	0	0%
0	0	0	0%
1	1	0	0%
28	28	0	0%
0	0	0	#####
39	39	0	0%
15	15	0	0%
15	15	0	0%
53	53	0	0%
53	53	0	0%
53	53	0	0%

Volume (vph)		Diff (vph)	%
Ex	Ch		
33	33	0	0%
0	0	0	0%
372	372	0	0%
0	0	0	#####
0	0	0	#####
1	1	0	0%
895	895	0	0%
9	9	0	0%
9	9	0	0%
146	146	0	0%
341	341	0	0%
5	5	0	0%
163	163	0	0%
1,949	1,949	0	0%
1,270	1,270	0	0%
1,343	1,343	0	0%
1,407	1,407	0	0%
341	341	0	0%
119	119	0	0%
73	73	0	0%
33	33	0	0%
90	90	0	0%
57	57	0	0%
19	19	0	-1%
8	8	0	-1%
11	11	0	-1%
11	11	0	-1%
9	9	0	-1%
10	10	0	-1%
5	4	0	-2%
6	6	0	-2%
2	2	0	-6%
2	2	0	-6%
1	0	0	-20%
4	4	0	-2%
12	12	0	-1%
13	13	0	-1%
125	125	0	0%
328	328	0	0%
421	421	0	0%
217	217	0	0%
171	171	0	0%
20	20	0	-1%
28	28	0	-1%
20	20	0	-1%
11	10	0	-2%
11	10	0	-2%
10	9	0	-2%
16	16	0	-1%
2	1	0	-13%
2	2	0	-9%
101	101	0	0%
46	45	0	0%
140	140	0	0%
140	140	0	0%

Volume (vph)		Diff (vph)	%
Ex	Ch		
140	140	0	0%
1,469	1,469	0	0%
427	427	0	0%
1,729	1,729	0	0%
299	299	0	0%
1,919	1,918	0	0%
589	589	0	0%
218	218	0	0%
254	253	0	0%
80	79	0	0%
12	12	0	-2%
12	12	0	-2%
14	13	0	-2%
1	1	0	-27%
2	2	0	-14%
23	22	0	-1%
9	8	0	-4%
13	13	0	-2%
10	10	0	-3%
10	10	0	-3%
407	406	0	0%
99	99	0	0%
1,232	1,231	0	0%
931	930	0	0%
413	413	0	0%
5	4	0	-9%
3	3	0	-13%
9	9	0	-4%
10	10	0	-4%
16	16	0	-3%
10	10	0	-4%
3	3	0	-12%
20	20	0	-2%
101	101	0	0%
142	142	0	0%
1,631	1,631	0	0%
1,271	1,270	-1	0%
3	2	-1	-20%
775	774	-1	0%
13	12	-1	-4%
89	89	-1	-1%
1,406	1,405	-1	0%
65	65	-1	-1%
8	8	-1	-6%
126	125	-1	0%
169	168	-1	0%
78	77	-1	-1%
6	6	-1	-10%
9	8	-1	-7%
6	6	-1	-10%
7	7	-1	-8%
25	25	-1	-2%
16	16	-1	-4%
17	16	-1	-4%
53	52	-1	-1%

Volume (vph)		Diff (vph)	%
Ex	Ch		
44	43	-1	-1%
66	65	-1	-1%
66	65	-1	-1%
681	680	-1	0%
931	930	-1	0%
309	308	-1	0%
427	426	-1	0%
264	264	-1	0%
264	263	-1	0%
6	5	-1	-11%
20	20	-1	-3%
103	102	-1	-1%
1,631	1,630	-1	0%
547	546	-1	0%
215	214	-1	0%
67	66	-1	-1%
67	66	-1	-1%
37	36	-1	-2%
8	7	-1	-10%
3	2	-1	-28%
21	21	-1	-4%
35	34	-1	-2%
60	59	-1	-1%
310	310	-1	0%
331	330	-1	0%
393	392	-1	0%
239	238	-1	0%
1,419	1,418	-1	0%
283	282	-1	0%
331	330	-1	0%
547	546	-1	0%
29	28	-1	-3%
19	18	-1	-5%
14	13	-1	-6%
3	2	-1	-31%
3	2	-1	-31%
3	2	-1	-31%
3	2	-1	-31%
21	20	-1	-4%
47	46	-1	-2%
215	214	-1	0%
269	268	-1	0%
1,743	1,742	-1	0%
222	221	-1	0%
49	48	-1	-2%
999	998	-1	0%
8	7	-1	-12%
8	7	-1	-12%
11	10	-1	-9%
8	7	-1	-12%
491	490	-1	0%
331	330	-1	0%
67	66	-1	-2%
26	25	-1	-4%
24	22	-1	-5%

Volume (vph)		Diff (vph)	%
Ex	Ch		
5	4	-1	-23%
15	14	-1	-7%
78	77	-1	-1%
222	221	-1	0%
331	330	-1	0%
930	929	-1	0%
730	729	-1	0%
487	486	-1	0%
467	466	-1	0%
153	152	-1	-1%
374	373	-1	0%
47	46	-1	-3%
78	77	-1	-2%
34	33	-1	-4%
156	155	-1	-1%
1,686	1,685	-1	0%
673	671	-1	0%
38	37	-1	-3%
6	5	-1	-22%
34	33	-1	-4%
111	109	-1	-1%
61	60	-1	-2%
137	136	-1	-1%
78	77	-1	-2%
1,231	1,230	-1	0%
333	332	-1	0%
671	669	-1	0%
451	450	-1	0%
110	109	-1	-1%
110	109	-1	-1%
38	37	-1	-4%
162	161	-1	-1%
1,167	1,166	-1	0%
4	3	-2	-34%
52	51	-2	-3%
719	718	-2	0%
129	127	-2	-1%
16	15	-2	-9%
49	48	-2	-3%
9	8	-2	-16%
36	35	-2	-4%
17	16	-2	-9%
17	16	-2	-9%
17	16	-2	-9%
116	115	-2	-1%
36	34	-2	-4%
276	274	-2	-1%
911	909	-2	0%
80	78	-2	-2%
52	50	-2	-3%
96	95	-2	-2%
45	44	-2	-3%
375	374	-2	0%
511	509	-2	0%
17	15	-2	-9%

Volume (vph)		Diff (vph)	%
Ex	Ch		
90	89	-2	-2%
80	79	-2	-2%
511	509	-2	0%
1,267	1,265	-2	0%
931	929	-2	0%
171	170	-2	-1%
319	318	-2	-1%
294	292	-2	-1%
376	374	-2	0%
203	201	-2	-1%
467	466	-2	0%
57	55	-2	-3%
95	93	-2	-2%
10	9	-2	-16%
12	10	-2	-14%
27	26	-2	-6%
52	50	-2	-3%
228	227	-2	-1%
245	243	-2	-1%
1,737	1,735	-2	0%
1,419	1,417	-2	0%
1,419	1,417	-2	0%
1,419	1,417	-2	0%
447	446	-2	0%
731	729	-2	0%
1,470	1,468	-2	0%
28	26	-2	-7%
16	14	-2	-12%
63	61	-2	-3%
468	466	-2	0%
625	623	-2	0%
720	718	-2	0%
115	113	-2	-2%
11	9	-2	-18%
56	54	-2	-3%
20	18	-2	-9%
20	18	-2	-9%
32	30	-2	-6%
125	123	-2	-2%
254	252	-2	-1%
85	83	-2	-2%
408	406	-2	0%
20	18	-2	-10%
20	18	-2	-10%
468	466	-2	0%
731	729	-2	0%
243	241	-2	-1%
27	24	-2	-8%
20	18	-2	-10%
60	58	-2	-3%
20	18	-2	-10%
20	18	-2	-10%
586	584	-2	0%
679	677	-2	0%
276	274	-2	-1%

Volume (vph)		Diff (vph)	%
Ex	Ch		
689	687	-2	0%
310	307	-2	-1%
307	305	-2	-1%
1,393	1,390	-2	0%
217	215	-2	-1%
433	431	-2	-1%
406	404	-2	-1%
182	180	-2	-1%
219	216	-2	-1%
1,393	1,390	-2	0%
657	655	-2	0%
655	653	-2	0%
961	959	-2	0%
27	24	-2	-9%
27	24	-2	-9%
7	5	-2	-34%
282	279	-2	-1%
320	318	-2	-1%
203	200	-2	-1%
41	38	-2	-6%
18	16	-2	-13%
18	16	-2	-13%
42	40	-2	-6%
123	121	-2	-2%
122	120	-2	-2%
538	536	-2	0%
97	94	-3	-3%
625	623	-3	0%
1,050	1,048	-3	0%
97	94	-3	-3%
1,165	1,162	-3	0%
448	445	-3	-1%
333	331	-3	-1%
436	434	-3	-1%
252	249	-3	-1%
19	16	-3	-14%
1,655	1,653	-3	0%
17	14	-3	-15%
41	38	-3	-6%
63	61	-3	-4%
50	48	-3	-5%
1,633	1,630	-3	0%
181	178	-3	-1%
60	57	-3	-4%
97	94	-3	-3%
212	209	-3	-1%
314	311	-3	-1%
643	641	-3	0%
1,164	1,162	-3	0%
976	974	-3	0%
205	202	-3	-1%
136	133	-3	-2%
1,190	1,188	-3	0%
1,419	1,416	-3	0%
656	653	-3	0%

Volume (vph)		Diff (vph)	%
Ex	Ch		
645	642	-3	0%
158	155	-3	-2%
8	6	-3	-33%
12	10	-3	-23%
8	6	-3	-33%
9	6	-3	-32%
171	168	-3	-2%
1,751	1,748	-3	0%
75	72	-3	-4%
8	6	-3	-35%
21	18	-3	-14%
56	53	-3	-5%
1,270	1,267	-3	0%
674	671	-3	0%
607	604	-3	0%
443	440	-3	-1%
515	512	-3	-1%
181	178	-3	-2%
645	642	-3	0%
199	196	-3	-2%
28	25	-3	-11%
28	25	-3	-11%
28	25	-3	-11%
27	24	-3	-12%
67	64	-3	-5%
544	541	-3	-1%
308	305	-3	-1%
516	513	-3	-1%
1,748	1,745	-3	0%
1,170	1,166	-3	0%
295	291	-3	-1%
375	372	-3	-1%
375	372	-3	-1%
120	117	-3	-3%
67	64	-3	-5%
65	61	-3	-5%
23	20	-3	-14%
32	29	-3	-10%
1,190	1,187	-3	0%
1,751	1,748	-3	0%
1,170	1,167	-3	0%
79	75	-3	-4%
509	505	-3	-1%
353	350	-3	-1%
465	462	-3	-1%
508	505	-3	-1%
377	374	-3	-1%
516	513	-3	-1%
85	82	-3	-4%
16	12	-3	-22%
61	58	-3	-6%
33	29	-3	-10%
169	166	-3	-2%
717	714	-4	0%
509	505	-4	-1%

Volume (vph)		Diff (vph)	%
Ex	Ch		
1,117	1,113	-4	0%
544	541	-4	-1%
50	47	-4	-7%
174	171	-4	-2%
154	150	-4	-2%
207	203	-4	-2%
1,597	1,594	-4	0%
22	18	-4	-16%
656	652	-4	-1%
106	102	-4	-3%
174	170	-4	-2%
68	64	-4	-5%
204	200	-4	-2%
203	199	-4	-2%
203	199	-4	-2%
544	541	-4	-1%
295	292	-4	-1%
545	541	-4	-1%
1,628	1,624	-4	0%
68	64	-4	-5%
27	23	-4	-14%
68	64	-4	-5%
79	75	-4	-5%
102	98	-4	-4%
26	23	-4	-14%
910	906	-4	0%
638	635	-4	-1%
672	669	-4	-1%
158	155	-4	-2%
529	525	-4	-1%
529	525	-4	-1%
9	5	-4	-44%
338	334	-4	-1%
205	201	-4	-2%
529	525	-4	-1%
204	200	-4	-2%
682	678	-4	-1%
194	190	-4	-2%
61	57	-4	-7%
27	23	-4	-15%
380	376	-4	-1%
297	293	-4	-1%
288	284	-4	-1%
288	284	-4	-1%
541	537	-4	-1%
682	678	-4	-1%
462	458	-4	-1%
116	111	-4	-4%
541	537	-4	-1%
679	674	-4	-1%
563	559	-4	-1%
257	253	-4	-2%
146	141	-4	-3%
146	141	-4	-3%
205	201	-4	-2%

Volume (vph)		Diff (vph)	%
Ex	Ch		
146	141	-4	-3%
146	141	-4	-3%
146	141	-4	-3%
144	139	-4	-3%
316	311	-4	-1%
853	849	-4	-1%
149	144	-4	-3%
145	141	-4	-3%
304	299	-4	-1%
1,285	1,281	-4	0%
612	608	-4	-1%
12	7	-5	-38%
146	141	-5	-3%
435	430	-5	-1%
932	928	-5	0%
2,211	2,206	-5	0%
144	139	-5	-3%
29	25	-5	-15%
33	28	-5	-14%
260	255	-5	-2%
1,830	1,826	-5	0%
76	72	-5	-6%
175	170	-5	-3%
373	369	-5	-1%
2,211	2,206	-5	0%
434	430	-5	-1%
98	94	-5	-5%
1,670	1,665	-5	0%
1,185	1,180	-5	0%
558	553	-5	-1%
315	310	-5	-2%
1,600	1,595	-5	0%
180	175	-5	-3%
295	291	-5	-2%
469	465	-5	-1%
127	122	-5	-4%
94	89	-5	-5%
95	90	-5	-5%
94	90	-5	-5%
1,551	1,546	-5	0%
601	596	-5	-1%
1,105	1,100	-5	0%
268	263	-5	-2%
435	429	-5	-1%
809	804	-5	-1%
470	464	-5	-1%
269	263	-5	-2%
68	63	-5	-8%
1,201	1,196	-5	0%
1,727	1,722	-5	0%
634	629	-5	-1%
68	63	-5	-8%
146	141	-5	-4%
2,212	2,206	-5	0%
301	296	-6	-2%

Volume (vph)		Diff (vph)	%
Ex	Ch		
148	143	-6	-4%
388	382	-6	-1%
46	41	-6	-12%
852	847	-6	-1%
15	9	-6	-37%
15	9	-6	-37%
932	926	-6	-1%
852	846	-6	-1%
1,115	1,110	-6	-1%
301	295	-6	-2%
634	628	-6	-1%
1,056	1,050	-6	-1%
1,468	1,462	-6	0%
182	176	-6	-3%
47	41	-6	-12%
452	446	-6	-1%
516	510	-6	-1%
516	510	-6	-1%
516	510	-6	-1%
591	585	-6	-1%
544	538	-6	-1%
757	751	-6	-1%
1,056	1,050	-6	-1%
1,295	1,289	-6	0%
138	132	-6	-4%
375	369	-6	-2%
583	576	-6	-1%
162	156	-6	-4%
757	751	-6	-1%
358	352	-6	-2%
127	121	-6	-5%
127	121	-6	-5%
21	14	-6	-30%
1,872	1,866	-6	0%
1,295	1,288	-6	0%
1,224	1,218	-6	-1%
1,295	1,289	-6	0%
38	32	-6	-17%
480	473	-6	-1%
1,831	1,825	-6	0%
625	619	-7	-1%
1,179	1,173	-7	-1%
1,061	1,055	-7	-1%
583	576	-7	-1%
1,467	1,460	-7	0%
193	186	-7	-3%
601	594	-7	-1%
505	498	-7	-1%
1,468	1,461	-7	0%
1,831	1,825	-7	0%
316	309	-7	-2%
120	114	-7	-6%
642	635	-7	-1%
536	529	-7	-1%
642	636	-7	-1%

Volume (vph)		Diff (vph)	%
Ex	Ch		
142	135	-7	-5%
1,744	1,737	-7	0%
1,468	1,461	-7	0%
228	221	-7	-3%
1,004	997	-7	-1%
1,225	1,218	-7	-1%
1,225	1,218	-7	-1%
227	220	-7	-3%
1,192	1,185	-7	-1%
600	593	-7	-1%
912	904	-7	-1%
135	128	-7	-5%
229	222	-7	-3%
425	417	-8	-2%
1,872	1,864	-8	0%
357	350	-8	-2%
74	66	-8	-10%
393	386	-8	-2%
1,628	1,620	-8	0%
216	208	-8	-4%
236	228	-8	-3%
319	311	-8	-2%
1,041	1,033	-8	-1%
200	192	-8	-4%
924	916	-8	-1%
200	192	-8	-4%
236	228	-8	-3%
1,628	1,620	-8	0%
393	385	-8	-2%
442	434	-8	-2%
130	122	-8	-6%
130	122	-8	-6%
869	861	-8	-1%
209	201	-8	-4%
1,793	1,785	-8	0%
48	40	-8	-17%
743	735	-8	-1%
40	32	-8	-21%
237	229	-8	-4%
924	916	-9	-1%
676	667	-9	-1%
1,696	1,688	-9	-1%
503	494	-9	-2%
1,155	1,147	-9	-1%
503	494	-9	-2%
1,794	1,785	-9	-1%
149	140	-9	-6%
1,086	1,077	-9	-1%
1,694	1,685	-9	-1%
1,191	1,182	-9	-1%
869	860	-9	-1%
1,674	1,665	-9	-1%
1,171	1,162	-9	-1%
925	916	-10	-1%
1,083	1,073	-10	-1%

Volume (vph)		Diff (vph)	%
Ex	Ch		
1,087	1,077	-10	-1%
253	244	-10	-4%
691	681	-10	-1%
658	648	-10	-1%
1,190	1,181	-10	-1%
73	63	-10	-13%
94	84	-10	-10%
379	369	-10	-3%
785	775	-10	-1%
1,871	1,861	-10	-1%
299	289	-10	-3%
297	287	-10	-3%
77	67	-10	-13%
585	575	-10	-2%
251	241	-10	-4%
1,854	1,844	-10	-1%
1,386	1,376	-10	-1%
585	575	-10	-2%
657	647	-10	-2%
333	323	-10	-3%
506	496	-11	-2%
1,854	1,844	-11	-1%
697	687	-11	-2%
380	369	-11	-3%
657	647	-11	-2%
227	216	-11	-5%
245	234	-11	-4%
442	431	-11	-2%
1,045	1,034	-11	-1%
682	671	-11	-2%
145	134	-11	-8%
567	556	-11	-2%
442	431	-11	-2%
130	119	-11	-8%
75	64	-11	-15%
409	398	-11	-3%
690	678	-11	-2%
682	671	-11	-2%
408	396	-11	-3%
792	781	-12	-1%
567	555	-12	-2%
1,510	1,498	-12	-1%
1,770	1,758	-12	-1%
792	781	-12	-1%
1,510	1,498	-12	-1%
1,510	1,498	-12	-1%
703	692	-12	-2%
990	978	-12	-1%
1,770	1,758	-12	-1%
1,770	1,758	-12	-1%
97	85	-12	-12%
2,064	2,052	-12	-1%
2,064	2,052	-12	-1%
1,675	1,662	-12	-1%
673	661	-12	-2%

Volume (vph)		Diff (vph)	%
Ex	Ch		
2,064	2,052	-12	-1%
535	522	-12	-2%
198	186	-12	-6%
335	323	-13	-4%
1,489	1,477	-13	-1%
716	704	-13	-2%
1,543	1,531	-13	-1%
367	354	-13	-3%
196	184	-13	-6%
97	84	-13	-13%
539	526	-13	-2%
152	139	-13	-8%
118	105	-13	-11%
118	105	-13	-11%
367	354	-13	-4%
2,111	2,098	-13	-1%
152	139	-13	-9%
332	319	-13	-4%
675	662	-13	-2%
1,708	1,695	-13	-1%
225	212	-13	-6%
119	106	-13	-11%
2,111	2,098	-13	-1%
2,112	2,098	-14	-1%
470	457	-14	-3%
621	607	-14	-2%
1,271	1,257	-14	-1%
135	121	-14	-10%
470	457	-14	-3%
207	193	-14	-7%
655	641	-14	-2%
313	299	-14	-4%
510	496	-14	-3%
534	520	-14	-3%
771	757	-14	-2%
1,537	1,523	-14	-1%
1,720	1,705	-14	-1%
655	641	-14	-2%
264	249	-14	-5%
368	353	-14	-4%
177	162	-14	-8%
177	162	-14	-8%
718	704	-14	-2%
534	520	-14	-3%
1,272	1,257	-14	-1%
707	693	-14	-2%
177	162	-14	-8%
93	79	-15	-16%
1,386	1,372	-15	-1%
615	600	-15	-2%
108	93	-15	-14%
544	529	-15	-3%
1,274	1,259	-15	-1%
1,499	1,484	-15	-1%
1,773	1,758	-15	-1%

Volume (vph)		Diff (vph)	%
Ex	Ch		
708	693	-15	-2%
1,450	1,435	-15	-1%
1,512	1,497	-15	-1%
108	92	-15	-14%
1,113	1,097	-15	-1%
684	668	-15	-2%
708	693	-15	-2%
369	354	-15	-4%
253	238	-16	-6%
1,777	1,761	-16	-1%
23	7	-16	-70%
22	7	-16	-70%
23	7	-16	-70%
525	509	-16	-3%
1,451	1,434	-16	-1%
701	684	-16	-2%
171	155	-16	-10%
1,115	1,098	-16	-1%
1,115	1,098	-17	-1%
867	850	-17	-2%
371	355	-17	-4%
860	844	-17	-2%
123	106	-17	-13%
1,500	1,484	-17	-1%
1,503	1,486	-17	-1%
1,115	1,099	-17	-1%
1,114	1,098	-17	-1%
153	136	-17	-11%
1,451	1,434	-17	-1%
727	710	-17	-2%
1,115	1,098	-17	-2%
689	672	-17	-2%
233	216	-17	-7%
162	144	-17	-11%
672	655	-17	-3%
673	655	-17	-3%
793	776	-17	-2%
234	217	-17	-7%
1,218	1,200	-18	-1%
153	136	-18	-11%
153	136	-18	-11%
585	567	-18	-3%
697	679	-18	-3%
663	645	-18	-3%
1,086	1,068	-18	-2%
638	620	-18	-3%
638	620	-18	-3%
603	585	-18	-3%
794	776	-18	-2%
1,219	1,200	-18	-1%
585	567	-18	-3%
380	362	-18	-5%
163	145	-18	-11%
794	776	-18	-2%
380	362	-19	-5%

Volume (vph)		Diff (vph)	%
Ex	Ch		
1,120	1,102	-19	-2%
1,218	1,200	-19	-2%
634	615	-19	-3%
1,218	1,200	-19	-2%
629	610	-19	-3%
628	609	-19	-3%
629	610	-19	-3%
166	146	-19	-12%
912	892	-19	-2%
1,115	1,096	-19	-2%
732	713	-20	-3%
731	712	-20	-3%
2,133	2,114	-20	-1%
389	370	-20	-5%
2,133	2,113	-20	-1%
731	711	-20	-3%
1,723	1,703	-20	-1%
725	705	-20	-3%
1,664	1,643	-20	-1%
1,723	1,702	-20	-1%
1,749	1,729	-20	-1%
1,513	1,493	-21	-1%
111	90	-21	-19%
484	464	-21	-4%
2,133	2,112	-21	-1%
111	90	-21	-19%
1,749	1,728	-21	-1%
2,207	2,186	-21	-1%
1,514	1,493	-21	-1%
1,206	1,185	-21	-2%
1,722	1,701	-21	-1%
678	656	-21	-3%
1,749	1,727	-21	-1%
421	399	-21	-5%
2,207	2,186	-21	-1%
309	288	-22	-7%
222	201	-22	-10%
185	163	-22	-12%
962	940	-22	-2%
1,439	1,417	-22	-2%
1,738	1,716	-22	-1%
2,207	2,185	-22	-1%
474	452	-22	-5%
474	452	-22	-5%
1,738	1,716	-22	-1%
1,555	1,532	-22	-1%
331	308	-22	-7%
139	117	-23	-16%
1,956	1,933	-23	-1%
618	595	-23	-4%
568	544	-24	-4%
697	673	-24	-3%
271	247	-24	-9%
697	673	-24	-3%
740	716	-24	-3%

Volume (vph)		Diff (vph)	%
Ex	Ch		
619	595	-24	-4%
189	165	-24	-13%
619	595	-24	-4%
253	229	-24	-10%
837	812	-24	-3%
104	80	-25	-23%
659	634	-25	-4%
254	229	-25	-10%
498	473	-25	-5%
175	150	-25	-14%
186	161	-25	-13%
498	473	-25	-5%
55	29	-25	-46%
55	29	-26	-47%
1,855	1,829	-26	-1%
620	594	-26	-4%
1,547	1,521	-26	-2%
2,169	2,143	-26	-1%
159	132	-26	-17%
2,169	2,143	-26	-1%
1,373	1,347	-26	-2%
341	314	-26	-8%
953	926	-27	-3%
2,170	2,143	-27	-1%
620	593	-27	-4%
641	614	-27	-4%
1,433	1,406	-27	-2%
621	594	-27	-4%
589	562	-27	-5%
591	564	-27	-5%
410	383	-28	-7%
948	920	-28	-3%
590	562	-28	-5%
953	925	-28	-3%
1,856	1,828	-28	-1%
948	920	-28	-3%
1,569	1,540	-28	-2%
410	382	-28	-7%
642	613	-28	-4%
621	592	-28	-5%
1,768	1,739	-29	-2%
1,405	1,376	-29	-2%
568	539	-30	-5%
1,546	1,516	-30	-2%
2,221	2,191	-31	-1%
40	9	-31	-77%
2,221	2,190	-31	-1%
1,354	1,323	-31	-2%
40	9	-31	-78%
40	9	-31	-78%
1,705	1,673	-32	-2%
796	764	-32	-4%
141	109	-32	-23%
141	109	-32	-23%
1,693	1,661	-32	-2%

Volume (vph)		Diff (vph)	%
Ex	Ch		
390	358	-32	-8%
162	129	-33	-20%
1,251	1,218	-34	-3%
208	174	-34	-16%
1,041	1,007	-34	-3%
1,041	1,007	-34	-3%
504	470	-34	-7%
1,675	1,641	-34	-2%
1,722	1,688	-34	-2%
752	717	-35	-5%
503	467	-36	-7%
504	468	-36	-7%
503	467	-37	-7%
1,304	1,268	-37	-3%
2,133	2,096	-37	-2%
826	789	-38	-5%
267	229	-38	-14%
2,133	2,095	-38	-2%
1,346	1,309	-38	-3%
1,331	1,294	-38	-3%
1,332	1,294	-38	-3%
1,477	1,440	-38	-3%
64	26	-38	-59%
267	229	-38	-14%
268	230	-38	-14%
698	660	-38	-5%
1,433	1,394	-39	-3%
698	659	-39	-6%
635	596	-39	-6%
2,206	2,167	-39	-2%
1,433	1,394	-40	-3%
1,585	1,544	-40	-3%
1,324	1,284	-40	-3%
1,327	1,287	-41	-3%
1,299	1,258	-41	-3%
978	936	-41	-4%
1,713	1,672	-41	-2%
1,325	1,283	-41	-3%
2,206	2,165	-41	-2%
1,497	1,455	-42	-3%
1,979	1,937	-42	-2%
601	558	-43	-7%
682	638	-44	-6%
727	683	-44	-6%
727	683	-45	-6%
812	767	-45	-6%
682	637	-45	-7%
812	766	-45	-6%
672	627	-46	-7%
2,058	2,012	-46	-2%
2,060	2,013	-47	-2%
2,059	2,011	-48	-2%
2,060	2,012	-48	-2%
2,070	2,022	-48	-2%
2,070	2,021	-49	-2%

Volume (vph)		Diff (vph)	%
Ex	Ch		
2,069	2,020	-49	-2%
2,023	1,973	-50	-2%
2,023	1,973	-50	-2%
283	231	-52	-18%
1,959	1,906	-53	-3%
1,959	1,906	-53	-3%
1,591	1,533	-58	-4%
814	756	-59	-7%
118	58	-60	-51%
1,245	1,184	-61	-5%
1,257	1,195	-63	-5%
1,914	1,851	-63	-3%
280	217	-63	-23%
1,915	1,851	-64	-3%
1,915	1,851	-64	-3%
722	656	-66	-9%
1,668	1,601	-67	-4%
1,668	1,601	-67	-4%
383	316	-67	-18%
379	312	-67	-18%
379	312	-67	-18%
379	311	-68	-18%
792	723	-69	-9%
655	584	-71	-11%
655	584	-71	-11%
776	704	-72	-9%
777	704	-73	-9%
1,735	1,659	-76	-4%
1,737	1,660	-78	-4%
463	376	-87	-19%
826	716	-110	-13%
475	363	-112	-24%
384	272	-112	-29%
474	362	-112	-24%
768	655	-113	-15%
768	654	-115	-15%
905	785	-120	-13%
905	784	-121	-13%
905	783	-122	-14%
860	734	-126	-15%
680	546	-134	-20%
924	774	-150	-16%
924	773	-151	-16%
305	118	-187	-61%
305	111	-194	-64%
374	151	-223	-60%